CONFERENCES - BRITISH EMPIRE EXHIBIT

Ministry of Agriculture and Fisheries.



BRITISH EMPIRE EXHIBITION

MDCCCCXXIV.

GUIDE

to the

Agricultural Exhibit

in

GALLERY II

of the

GOVERNMENT PAVILION.



Fleetway Press Ltd 3-9, Dane Street, High Holborn, London, W.C.1.

Price 6d.

COMMONWEALTH MYCOLOGICAL INSTITUTE

THE GALLERY FRIEZE.

The designs of the frieze which surrounds the walls of the Gallery illustrate the rural occupations of the months. They are copied from a Calendar, written in England in the eleventh century, which is in the British Museum. Copies of the scenes from another contemporary manuscript, reproduced on 12 pictorial postcards (Set 41), may be obtained at the Museum.

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" How can he get Wisdom that holdeth the Plough ? "

—Ecclesiasticus xxxviii, 25.

* * * * *

'Nothing is more wanting in agriculture than experiments in which all the circumstances are minutely and scientifically detailed."

—Sir Humphry Davy.

* * * * *

"As for the rest,
Thus think I best,
As friend doth guest,
With hand in hand to lead thee forth
To Ceres camp, there to behold
A thousand things. . . ."

—Thomas Tusser. A.D. 1557.

PREFACE.

The Agricultural Exhibit in the Government Building at the British Empire Exhibition is confined to research and education. Agricultural Education is not a subject naturally adapted to the purposes of an exhibtion where space is confined, and nothing more can be done than to show by means of a map the organisation of the specific agricultural institutions in the country.

Agricultural research likewise presents difficulties to the exhibitor : its range is immense, and even if the selection be confined to aspects of special practical value, the choice is still embarrassing. The present selection has been made for the most part by the investigators themselves in an attempt to outline, as it were, the story of work which is now being carried on at research institutions and laboratories in England, Scotland and Wales. To many this story will be quite new, and this Guide is intended for the assistance of those to whom the specimens in the cases are not wholly intelligible. In it an endeavour has been made to explain some of the main problems of farming, as these are presented by the soil, the plants that grow thereon, and the animals which these plants nurture.

Agricultural Research in Great Britain is not to any great extent conducted directly by the Government. The Ministry of Agriculture, it is true, and the Board of Agriculture for Scotland, whose position is similar to that occupied by the Ministry in England and Wales, do themselves undertake a certain amount of research, but the work is mainly performed at Institutions to which the State contributes financial support and supplies some measure of co-ordination. These Institutions are not necessarily creations of the State. Many owe their origin entirely to private munificence or individual enterprise, encouraged in some cases by promptings and promises of assistance from Government Departments. They are, however, independent organisations with their own governing bodies, free from interference on the part of the State. Their growth is of comparatively recent date.

Before the creation of the Development Fund in 1909, the assistance given by the State to agricultural research was trifling in amount, and the research carried on at the Universities, at Agricultural Colleges, and at Rothamsted was maintained almost entirely from private resources.

Even to-day any notice of agricultural research in Great Britain would be incomplete which did not take into consideration the by no means negligible amount of research and experiment which is being carried out by societies, by commercial firms and by private individuals. The Development Fund, however, enabled the Development Commissioners and the administrative Departments to frame a general policy of agricultural research under which the work to be done is definitely mapped out and allotted to specially equipped Institutions. The existence of such Institutions has in turn stimulated both the generosity of private benefactors and the interest of industries concerned with certain aspects of their work, and assistance has from time to time been forthcoming for promoting special lines of investigation and for increasing the resources of particular institutions. Although there is still a wide field for private munificence, it may yet be said that to-day there are few agricultural problems likely to yield to research upon which some work is not being done or for which researchers are not being trained.

The work which is displayed and illustrated in the Agricultural Gallery is the result of the happy co-operation of the State and independent researchers, made possible for the most part by the typically British expedient of grants-in-aid. This co-operation has extended to the selection and staging of these exhibits. For the preparation of the specimens the staffs of the Institutions to which reference is made in the following pages are responsible, and to them are due, for this and for many greater services, the thanks of all those interested in British agriculture. The Ministry is also indebted to Mr. E. I. Robson, M.A., for assistance in the preparation of this Guide.

Cinematograph films dealing with agricultural machinery, clean milk, sugar beet and improved varieties of wheat, have been prepared and will be shown regularly in the Government Pavilion during the period of the Exhibition.

A. D. HALL.

Ministry of Agriculture and Fisheries.

April, 1924.

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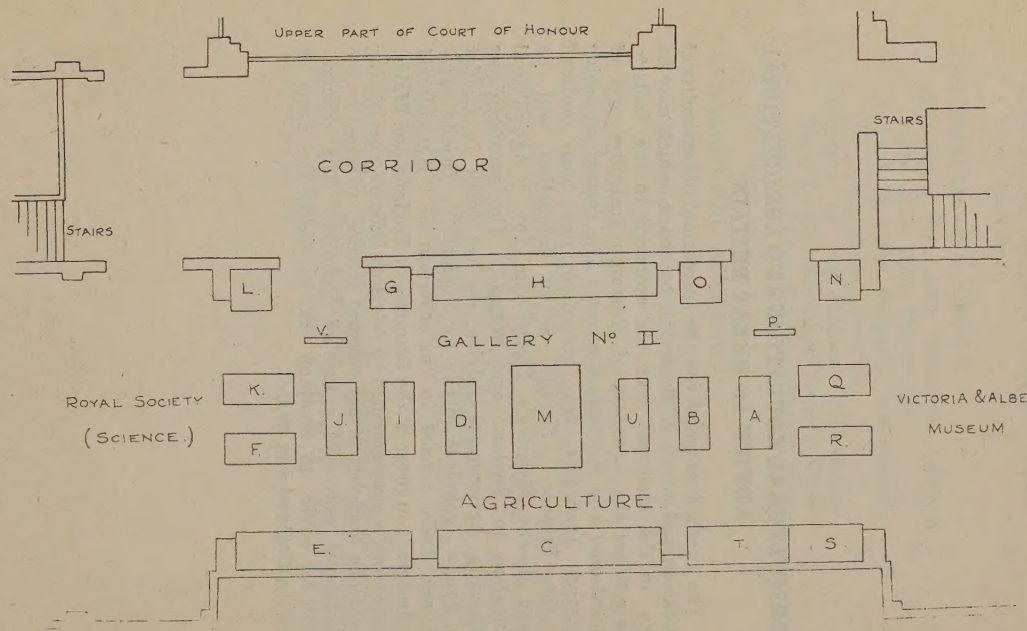
NOTE.—In addition to the above, the following Research Institutes should also be mentioned :—

The Plant Physiology Research Institute, Imperial College of Science, South Kensington ; The Research Institute in Animal Pathology, Royal Veterinary College, Camden Town, N.W.1. ; The Institute of Research in Agricultural Engineering, University of Oxford ; and The Institute of Animal Pathology, University of Cambridge.

For fuller information on Research Work in Great Britain the reader is referred to " Agricultural Research and the Farmer," obtainable at H.M. Stationery Office stall, price 2s. 6d.

AGRICULTURAL EDUCATION AND AGRICULTURAL ADVICE IN GREAT BRITAIN.

The method adopted for the provision of agricultural education and advice is illustrated by maps, which may be seen on the staircase near the entrance to the Gallery. These show the situation of Research Institutes and of Educational and Advisory Centres. The system on which Research Institutes are organised has been outlined in the Preface. Details as to Education will be found in the Ministry's Leaflet No. 197, "Agricultural Education in England and Wales." The arrangements respecting Agricultural Advice are set forth in Leaflet No. 279, "Technical Advice for Farmers." Briefly summarised, these consist in the provision of "Agricultural Organisers" in most of the Counties of England and Wales, whose work is supplemented by Advisory Officers, specialising in various branches of agricultural science, attached to the educational centres of groups of counties. The arrangements for advice in Scotland are, in effect, the same as those in England and Wales.



Plan of Gallery containing the Agricultural Research Exhibits.

(See references pp. 5-6.)

Guide to the Exhibits.

THE SOIL.

The exhibit of the **Rothamsted Experimental Station** (Cases A & B) is designed to illustrate the properties of the soil and some of the methods used for its improvement.

Good Tilth.

Every farmer and gardener knows that it is essential to get his land into "good heart" or into good "tilth" if his plants are to make satisfactory and healthy growth. A soil in this condition is crumbly, warm and moist, and easily worked; it retains sufficient moisture for good plant growth, and allows excess water to drain away easily. Some soils, especially those containing much clay—heavy soils—are liable to lose their good tilth if they are injudiciously treated. It is of great importance that we should know something of the scientific properties of the soil so that we may have a reliable basis for our study of such effects, and, for instance, of improved methods of cultivation.

What the Soil is like.

Scientific investigation of the soil is therefore necessary. Soil is a very complex mixture of particles of all shapes and sizes. If it were greatly magnified it would look something like Exhibit 1. Fortunately, very approximate calculations can sometimes be made, if, instead of an actual soil, a so-called "ideal" soil is considered, in which the particles are all spheres of equal size. Even then, although a very irregular arrangement is replaced by a regular one, the latter is still very complicated, as a study of the sections cut through models of an ideal soil will show (Exhibit 2).

The models show that soil is not a solid mass, but is permeated by innumerable crevices and channels. These openings are known as the pore space of the soil, and in this space both moisture and air will be found. The pore space forms a surprisingly large fraction of the total space occupied by the soil, varying between 25 and 50 per cent. of the total volume, according to the nature of the soil (Exhibit 3). Various manurial treatments, used by the farmer for producing a good tilth, have the effect of making the soil more open and porous, so that a given weight of manured soil occupies a larger total volume than the same weight of unmanured soil (Exhibit 4). This sponge or crumb-like structure of soil in good tilth has important

consequences in regulating the ease with which surplus water will drain away into the lower depths of soil. This is illustrated by the working model (Exhibit 5). Besides providing a proper habitat for plant roots, a soil in good tilth reduces the loss of water by evaporation from the soil surface. In Exhibit 6 is shown the surface of the same soil in bad tilth and good tilth. The hard clods of the former, separated by deep and wide cracks through which a large quantity of water evaporates and is lost to the plant, should be especially noted. It is not generally known how great are the needs of the plant for water compared with its demand for food. If the latter be represented by a column an inch high, the former would require on the same scale a column higher than the Nelson monument (Exhibit 7).

The process of producing a good seed bed, in good tilth, is a highly complex act, to which science is turning its attention. The working model of Exhibit 8 is intended to illustrate three important phases of soil cultivation employed for this purpose. In Exhibit 9, the action of the plough on the furrow slice is illustrated in more detail.

Measuring Work done.

The process of cultivation adds considerably to the cost of producing a crop, and for this reason alone it is necessary to examine the scientific aspects to see if an increase in efficiency and a reduction in cost can be made. The instrument used for this purpose is shown as Exhibit 10. It is known as a dynamometer, and is really an elaborate spring balance; it is placed between the tractor and the plough, and gives, on a moving chart, records of the drawbar pull, the speed of ploughing and the depth of ploughing.

Specimen records are shown as Exhibit 11. From a careful examination of these records it is possible to calculate the differences in power consumption brought about by various soils and manures, and thus to say what saving in power (in this case petrol or paraffin consumption) is achieved. Similar calculations can be made for variations in the shape of the plough itself, the speed of ploughing, &c. The percentage decreases are shown in Exhibit 12.

IMPROVEMENT OF PLANTS.

Plants may be improved by selection of superior forms, by breeding superior varieties, and by the process known as grafting. The origin of selection and grafting is lost in the mists of antiquity. The art of plant breeding, however, is based on the discovery, at the end of the seventeenth century, of the existence of sex in plants, and was, in common with animal breeding, placed on the footing of a science mainly by Mendel's discovery, made in 1865, but practically unknown until the first year of the present century. The ancients, before the Christian era, seem to have appreciated certain facts which can only be explained by the existence of sex in plants, but the explanation tarried for some twenty centuries.

Introduction.

The work which is being done in plant selection and plant breeding is illustrated by the exhibits (Cases C and D) from the **Plant Breeding Institute, Cambridge University, The Scottish Plant Breeding Station of the Scottish Society for Research in Plant Breeding,** and **The Welsh Plant Breeding Station of the University College of Wales, Aberystwyth.** The exhibit of the **National Institute of Agricultural Botany,** while also to some extent illustrating the scientific side of plant breeding, affords insight into the methods by which the work of the investigator is made available to the public. The institutions mentioned above are mainly concerned with farm crops proper ; improvement, on other lines, of trees and fruits, is illustrated by the exhibits (Cases E, F and G) of the **East Malling Research Station** and the **Agricultural and Horticultural Research Station of the University of Bristol,** while, though not immediately concerned with either breeding or grafting, the exhibit from the **Royal Horticultural Society's Gardens** (Case E) has much to teach of the methods adopted by Nature in multiplying the kindly fruits (and seeds) of the earth—methods which the plant breeder must study and adopt.

The exhibit (Case C) of the **Plant Breeding Institute of Cambridge University,** while illustrating the technique of crop improvement, is at the same time a useful object lesson of Mendel's discovery. Such features as beards or no beards, red chaff or white, rust resistance or rust susceptibility, &c., are all inherited independently of one another, and consequently by crossing suitable varieties fresh combinations can be obtained. The sheet

Wheat Breeding.

of specimens labelled "Two parent wheats: First cross between, and its progeny" shows in the bottom row the possible regroupings of the characteristics of the two parents. The grain of the parent plants differs also, one being "strong" (i.e., of good baking quality) and red, the other "weak" (or of poor baking quality) and white. The grain of the descendants of the first cross is of the four types shown, namely, strong red, strong white, weak red and weak white. The strong white and weak red show the regrouped characteristics of the two parents.

Where the parents differ in many respects the generation raised from the first cross contains large numbers of very diverse forms, as in the sheet showing some of those forms resulting from a cross between Rivet and Iron Wheat. Different as they are, each one is the result of fresh combinations of the characters found in the two parents, and its occurrence can be foreseen before making the cross.

To build up a perfect wheat then it is necessary to obtain, for using as parents, varieties in which one or more characteristics are as perfectly developed as possible, even if they are associated with undesirable features. The group labelled "Wheats used for cross breeding" shows a small collection of varieties, picked out after testing wheats from all parts of the world, which between them should produce the required type. (*a*) is a mildew-resisting form from Persia; (*b*) a form resistant to yellow rust from Duluth; (*d*) a good milling and baking form from Canada; (*e*) the old English wheat Rivet, valued chiefly for its straw; and (*f*) a heavy cropping hybrid. From the agricultural point of view most of these wheats are worthless in this country. Several of the best features have already been built into the heavy cropping English strains, and the specimen sheaves, labelled "strong-grained hybrid wheats," show new types now being tested at the Plant Breeding Institute at Cambridge.

The feature to which most attention has been paid is to secure the combination of heavy yielding capacity and good baking quality. The glazed boxes labelled "grain of strong hybrid wheats" show samples from hybrids known to crop at least as well as the ordinary English wheats. The loaf numbered 6 in the photograph in the adjoining exhibit of the National Institute of Agricultural Botany was made from grain of the sort marked H.H.

The series of specimen bunches labelled "New breeds of Spring Wheats" show the results of re-grouping the characteristic of many (i.e., more than four) grains per spikelet with the habit of maturing early. One of the

reasons why spring wheats fail to crop satisfactorily is that the ears are poorly set, a difficulty which, it appears, can be surmounted by building up new forms from appropriate parents.

Problems generally similar to those illustrated here are under investigation with most of the agricultural crops at the Plant Breeding Institute.

Oat Breeding.

The exhibit (Case C) of the **Scottish Plant Breeding Station** (**Scottish Society for Research in Plant Breeding**), **Craigs House, Corstorphine, Midlothian,** illustrates similar work with oats. The general aim is to produce improved varieties of the old-established Scottish types, such as "Potato," "Sandy", and "Tam Finlay." These all excel in hardiness, and in quality of grain and straw, but are capable of improvement in respect of yield and earliness of ripening. Naturally old-established types like these comprise a large variety of forms. The small sheaves on the right hand partition wall of the show case illustrate a few of the different forms of "Potato"—of which some 50 forms have already been identified— and of "Sandy" and "Tam Finlay."

Pedigree Culture (Isolation of Pure Lines).

The left-hand partition wall shows what are known as "pure lines" of the three oats, which have been isolated at the station. By "pure lines" or "fixed" strains are meant strains consisting of individuals which are identical in all essential characters and which all "breed true" for these characters in successive generations.

It is a simple matter to obtain pure lines in the case of a plant such as the oat, which is normally self-fertilised and in which accidental crosses, even between closely adjacent plants in a plot, are very rare. If the grain of a single plant is harvested separately and sown separately, a pure line is at once obtained, provided the selected plant was not a hybrid. Such pure lines, once isolated, may be perpetuated unchanged for an indefinite number of generations; many pure lines (of wheat) have already been grown in this way for over 50 years.

A pure line of superior character may be worth marketing as such. The main object of pedigree culture, however, is to secure uniform and constant types which can be utilised for hybridisation.

Hybridisation.

The object of hybridisation is the production of new varieties combining the desirable features of two (or, where repeated crossing is resorted to, of several) parents. At the Scottish Plant-Breeding Station the main idea, with oats, is to combine the hardiness and outstanding quality of the old Scottish types with the heavier yielding capacity or earlier ripening power of certain newer varieties, such as "Victory," "Leader" and "Eighty Day." The nature and behaviour of the heritable "factors" determining these properties are very imperfectly known, but it is certain that a considerable number of "factors" are involved. The second hybrid generation (F_2), obtained by self-fertilising the original hybrid (F_1) resulting from a cross between two varieties differing in a number of factors, will necessarily comprise a great variety of types, of which some will be more desirable than others. Moreover, any given type may or may not breed true in the further generations (F_3 and onwards).

Crossing is in fact only the first step in a long series of operations involving selection, pedigree culture and comparative trials. In general the "fixing" of a promising new type cannot be accomplished in less than five to six years from the original cross. This period will no doubt be reduced as more information is obtained regarding the heritable factors in oats; but three years from the cross is the irreducible minimum for "fixing" a type in any case.

Hybrid selections of various types and at various stages of development, some fixed and some unfixed, are illustrated by the large sheaves on the back wall of the show case, and small samples of the grain are exhibited in jars on the shelf. These selections are grown in small "breeding plots," each containing about 100 plants. Every plant is treated separately as regards harvesting, thrashing, determination of characters, etc., and the seeds are also sown individually by hand (25,000 oat-grains were thus sown individually in 1923).

Ear Types.

The series of photographs on the floor of the show case illustrates the principal types of ear or panicle which occur in oats. The inheritance of ear-type is not yet fully cleared up, and investigations on this point are being carried out at the Scottish Plant Breeding Station. Although the exact form of the ear is not in itself a matter of much practical significance, it is nevertheless essential that any new variety should breed true to one particular type of ear,

first, because ear-type may be correlated with other features, such as yield, which are of obvious economic importance, and further, because growers cannot be expected to place much confidence in the purity—in other respects—of a stock which is obviously mixed as regards the type of ear.

Other Plants.

Investigations on similar lines are in progress on several other crops, viz., Potatoes, Swedes and Turnips, and Herbage Plants. All interested in crop improvement are cordially invited to visit the Station, which is within easy reach of Edinburgh. The Director of Research will be glad to supply a copy of the Annual Report for 1923 to any person interested.

Grasses.

The exhibit (Case C) of the **Welsh Plant Breeding Station** illustrates the principle of plant breeding as applied to grasses. Since the Station was founded in 1919, with the main object of improving herbage plants—grasses and clovers—an endeavour has been made to collect as many as possible of the different strains of the chief species likely to be of value in this country. The variation which exists between different strains and nationalities of grasses has been carefully studied, and it is hoped, ultimately, by means of hybridisation, to combine desirable characteristics found in different plants.

Variation.

The variation found within a species is often very great, not only in the type of inflorescence, but equally in other characteristics, such as time of flowering, habit of growth, leafiness and productivity. Exhibit I is designed to demonstrate the extent of variation which may be found within a single species. Variation in type of inflorescence lends itself well to demonstration, and it may be regarded as an indication of the degree of variation found in other characters also. The inflorescences were each taken from different plants of Perennial Rye Grass (*Lolium perenne*). Each specimen illustrates the average type of inflorescence borne on the plant which it represents. The plants were grown under very similar conditions, so that the variation may confidently be assumed to be inherent rather than imposed by external conditions. Exhibit II shows the variation which takes place in the progeny of a single plant. In their natural state most grasses,

unlike wheat and oats, are normally cross-pollinated, the pollen being blown from one to another by the wind. In this case the parent plant (P) was protected so that it could not be cross-pollinated. Thus any seed obtained would be due to self-pollination. The other specimens show the variety in the plants obtained from this seed. Two inflorescences are shown for each plant—the shorter and more dense produced in the earlier and the other in the later part of the season.

The variation in the inflorescence, shown in both these exhibits, may be taken as an indication of the variation existing in other characteristics as well.

It will be seen from the two exhibits that in a grass species there is a very wide variation, so that there is ample room for selection. But when the selection is made, two difficulties arise. Not infrequently the plant will be incapable of producing progeny by self-pollination. This difficulty, it will be remembered, does not arise with wheat and oats. Secondly, the selected plant, even if it should be able to produce progeny by self-pollination, may produce, as is seen in Exhibit II, an exceedingly variable progeny, with the result that selection must begin all over again.

Exhibit III shows the difficulties which are met with when actual breeding work begins. Two parent plants of Tall Oat Grass are shown, one in which the internodes at the base of the stem are not swollen, and the other in which they are (*Arrhenatherum elatius* and its variety *tuberosum*). These two plants were artificially crossed, and from the seed thus gained a first generation (F_1) was produced, more or less intermediate between the two parents. One of the first generation (F_1) plants was then isolated and seed produced by self-pollination. The second generation (F_2) plants resulting from this seed show an exceedingly wide range of variation. None, in fact, of 370 plants raised display either as little bulb or as much bulb as the original parents, although all grades of intermediate types are present.

The bulbous type is, as a rule, more leafy than the bulb-less type. Supposing the two were crossed, in the hope of obtaining a leafy bulb-less type, such a type might not be found at all in the second generation, or only one such might be found among thousands of plants. This again when self-pollinated might not breed true to both characters.

The exhibit of the **National Institute of Agricultural Botany** is in Cases C and D. The Institute has three main branches—Crop Improvement, Potato Testing, and Seed Testing.* The Crop Improvement Branch aims at affording facilities for the testing, on a field scale, and eventual introduction of new forms of agricultural plants, produced either by Plant Breeding Institutes or by other workers. Breeders who enter their productions for the trials may either themselves introduce them to the market or entrust them to the Institute on profit-sharing terms.

Crop Improvement.

The method employed in testing cereals—at present the main work of this branch of the Institute—is shown by models, diagrams and photographs. According to this method, which may be termed "the drill strip system," the new crop is, in the first year, grown side by side with some well known, established form with a view to obtaining seed of both forms grown under identical conditions. In the following seasons the seed so obtained is sown from the same drill, which feeds to the coulters on one half of its breadth the new form, and on the other half the standard or "control" form. In this way any number of strips (usually 20, each containing 1/20th acre) can be laid out, one strip of the new form, and another of the "control," alternately. Since the two are thus grown side by side, and as many comparisons can be made as there are pairs of drill strips, greater accuracy is obtained than by plot trials as hitherto conducted. The accuracy is increased by cutting away portions between the strips so as to obviate any possible "interference" between the two forms. Moreover every such test of a new cereal is conducted for at least two years and at five or six widely-separated centres before the final results are published. Some of the forms of cereals at present under trial are shown by dried specimens. Dried specimens are also shown of some of the large reference collection of cereals, which are grown at the Institute. These include old English forms, now no longer generally cultivated but still of possible service to plant breeders, some

Field Scale Tests of Cereals.

* The exhibit of the Crop Improvement Branch will be shown from 15th May until 12th June, and from 17th July to 14th August. The exhibit of the Potato Testing Branch will be shown from the date of opening until 15th May and from 14th August to 11th September. The exhibit of the Seed Testing Station will be shown from 12th June to 17th July.

recently introduced forms, and specimens of "synonymous" forms which, though sold under different names, are, in fact, identical.

Wart Disease of Potatoes.

The exhibit illustrating the potato work of the Institute shows how Wart Disease (*Synchytrium endobioticum*)—the most destructive of all potato diseases -is being combated by legislation and by science. In 1908 the disease was made notifiable, and stringent regulations were made by the Ministry of Agriculture to prevent its spread. The chart shows how successful these efforts have been. The Ministry's system of inspection also ensures that seed potatoes grown in England carry with them no risk of infection. The discovery in 1910 that certain forms of potatoes were immune led to a greatly-increased interest in potato breeding. Practically all new potatoes are now sent to the **Potato Testing Station at Ormskirk, Lancashire,** where they are grown in highly-infected soil. If after two or three years' trial they show no trace of infection, they are approved by the Ministry as immune. There are now immune varieties on the market quite as good as any commercial varieties of ten years ago, and clean crops can be grown on the most highly-infected soil. Preserved specimens of some of these varieties, grown by the Institute and prepared for exhibition and lent by the Ministry of Agriculture, are shown in the exhibit.

Yield and Maturity of Potatoes.

Another model illustrates the method used by the Institute to determine the comparative yield of different forms of potatoes, and the time which they take to ripen. Tables are shown which give the results of trials carried out by this method, which marks a great advance in reliability.

Potato Breeding.

Further exhibits, shown by Dr. R. N. Salaman, of Barley, Herts, illustrate genetic and other characters in the potato. As is well known, potatoes are never grown commercially from true seed—what is known as "seed" of potatoes are whole tubers or fragments of tubers. The fruit, properly speaking, which contains the true seed, is what is popularly known as the potato apple. No. 1 shows the wide variety of forms which occur in breeding both from wild and cultivated varieties. *Solanum edinense*, a wild variety, gives rise, when self-pollinated, to

wild and wayward forms in addition to others which are indistinguishable from domestic varieties. In No. 2 is seen a prostrate potato plant. Owing to the shade it affords to the soil it can resist drought better than ordinary varieties. No. 3 shows a tuber mutation in "Golden Wonder," producing a variety indistinguishable from "Langworthy." In No. 4 are illustrated experiments in the inheritance of the colour of the skin of the potato tuber. These experiments show that the colour of the skin follows Mendel's law of inheritance. Consequently when the breeder wishes to raise white-skinned varieties, such as are desired for table purposes, the use of coloured parents is not ruled out. No. 5 illustrates heredity of colour in the flower of the potato plant, and the distinction between colour disposition in domestic varieties and in several of the wild varieties. No. 6 shows examples of correlation between flower characters and colours of tubers by which a breeder may recognise in many cases the type of tuber which a seedling will bear, before the tubers may be formed. In No. 7 are to be seen experiments on the heredity of immunity to Wart Disease. These show that immunity depends on several hereditary factors, hence there are various types of immune plants. Susceptibility to Wart Disease is of two kinds. Either the variety is destitute of all the characters which confer immunity, or though some "immune" factors are present, their action is defeated by the presence of other factors. Most susceptible varieties are of the former class; Myatt's Ashleaf and President are examples of the latter class. No. 8 shows the use of the "leaf index" in determining whether varieties are synonymous or distinct. The leaf index is the average ratio of the breadth to the length of the lateral leaflet nearest the apex of an adult leaf. This ratio is always the same for any one variety.

Seed Testing.

The photographs and apparatus which form the Exhibit of the **Official Seed Testing Station** illustrate the work done in testing the purity (freedom from weed seeds, etc.) and the germinating capacity of seeds. The station issues purity and germination reports on samples of seeds received from sellers to enable them to comply with the Seeds Act, 1920*; it also provides similar reports at specially low rates for the information of purchasers, or of farmers who grow their own seeds. Research work is also undertaken on seed testing problems with a view

* See Form 728/C.S., "The Seeds Regulations, 1922," obtainable from the Ministry.

to improving the methods employed at the official Station and for the information of the private stations licensed by the Ministry to test seeds.

The Station was established by the Ministry in London in 1917, and transferred to a specially designed building at Cambridge in 1921, and is now managed by the Institute on behalf of the Ministry.

Visits to the National Institute of Agricultural Botany.

All who are interested in the work of the Institute are invited to visit its headquarters at Huntingdon Road, Cambridge, and its Potato Testing Station at Lathom Road, Ormskirk, Lancashire, which are open for inspection on any week-day from 9.30 a.m. to 5 p.m. (Saturday 9.30 a.m. to 12 noon). Headquarters are reached by express train from Liverpool Street or King's Cross Stations in about one-and-a-half hours; thence by 'bus to Oxford Road to within half a mile of the Institute. Visitors to the Potato Testing Station travel from Euston to Liverpool (Lime Street Station), and thence by local train from the Exchange Station to Ormskirk. Intending visitors are recommended to advise the Secretary of the date of their visit. At Cambridge visitors can see the testing of seeds for purity and germination; yield trials of wheat, comparative plots of Lucernes, Grasses, Clovers, Peas and Swedes, and a living herbarium of over 400 different cereals; and at Ormskirk the Wart Disease trials, yield and maturity trials of first early potatoes, demonstration plots of commercial forms of potatoes, and yield trials of wheat.

Fruit Trees.

The exhibit (Case E) from the **Research Station, East Malling, Kent (The Kent Incorporated Society for the Promotion of Experiments in Horticulture)**, deals with methods employed in the greater control of fruit trees by means of the selection and standardisation of their roots.

Fruit trees of named varieties are not grown from seeds. The chief reason for this is that the seedlings, as will be seen from Photographs 1, a-d, usually differ considerably from their parents. Again, the great majority of the apples and pears and many of the plums and cherries of our orchards do not readily form roots of their own. If they do take root, they usually develop at first more slowly than when grafted upon another root (Specimens 2b and 2c). Hence, fruit trees generally consist of two

distinct parts—(a) the "Scion," i.e., the graft or bud of the named variety (Specimen 3a); (b) the "Stock," i.e., the distinct root system (Specimen 3b).

Stocks and Scions.

These are made to unite (Specimen 3c to 3e) and form a complete tree (Specimen 3f). It may be asked: What is the effect of the root stock on the tree? Tradition said that the kind of root stock influenced the tree (see Hitt's "Treatise," 4a), but how much and in what ways has not been accurately known. Again, adjacent trees of a single variety, similarly treated, often show striking differences in growth and cropping (Photographs 5b and 5c, and Diagram 1, 5d). It was suspected that this was largely due to mixed root stocks. To reduce these differences it was necessary first to find out what kinds of root stock were in use, then to see in what ways they influenced the tree, and having settled these two points, to select the best for particular purposes. What was found out about the root stocks in use? Apple stocks, to take apples as an example, were reputed to be of two main kinds: (1) "Crab" and "Free" stocks raised from seed, all of which were supposed to be vigorous, but which actually differed greatly*; (2) so-called "Paradise" and "Doucin" stocks, raised from layers or cuttings (Specimen 7-a, b, c, d, e). All of these were supposed to be dwarfing, and true to type and name. As a matter of fact, there were at least 17 varieties which differed greatly and were badly mixed together. Among the 17 varieties, types were found both vigorous and dwarfing, and coarse and fibrous rooted. (Photographs 8f and 8g, Specimens k and l). Once the varieties had been sorted out by studying their botanical characteristics (Specimens 8b and 8c), it was possible, by layering, to raise uniform stocks from any of them. Having determined the differences between these layered stocks, it became possible to study the way in which they affect the tree. It was found that different varieties affect the tree very differently, not only in size, habit of growth and fruiting, but also in earliness of blossoming and fruiting (Photographs 9-b and c, e and f, n and p, and Specimens 9-h, j, k and l). What is the practical outcome of this, or, in other words, how does it affect the fruit-grower? By taking advantage of these differences

Stocks from Layers or Cuttings.

* For further information as to "Crab" and "Free" stocks reference should be made to the exhibit from the Agricultural and Research Station of the University of Bristol. (Case G. See p. 26 of this Guide.)

the grower can largely control the size and cropping of his trees. The use of dwarfing root stocks should prevent overcrowding and save the amateur from unnecessary root pruning in the garden (Photographs 10a and 10b). For the small garden, dwarf, quick-cropping trees are ideal (Photographs 10e and 10f). In the orchard, the commercial grower, by a proper choice of root stock, can alternate the dwarf quick-cropping "filler" tree with the slow-developing "permanent" tree (Photograph and Plan 10h), and thus avoid both long waiting for returns, and in the end an overcrowded orchard (Photographs 10l and 10m). And the research worker, to whom both amateur and commercial grower must look for help, has uniform material for his experiments.

How does the Stock affect the Tree?

The remaining exhibits illustrate the effects of the stock upon the tree. Table I, No. 11, shows, by figures, how different root stocks affect the same variety of tree. As a result, layered apple stocks may now be grouped as follows: (a) Very dwarfing stocks, suitable for very small quick-cropping trees; (b) semi-dwarfing stocks, suitable for quick-cropping trees of moderate size; (c) vigorous stocks, suitable for large bushes and weaker growing varieties; (d) very vigorous stocks, suitable for large standard trees, and the weakest growing varieties (Photographs 12—b, c, d and e). By a proper choice of these the activities of the tree can, to a large extent, be controlled (Diagram II, 12f). Besides the size of the tree and the earliness of its cropping, the number and position of blossom buds, the percentage of blossom which develops into fruit, the actual quantity and quality of that fruit, and the health of the tree itself are all affected.

Some stocks give the tree a better roothold than others. Some will cause the tree to blossom later in the season—an advantage in frosty places (see Table II, 13c, Photographs 13e and 13f). They may affect the size, colour and quality of the fruit; and, finally, some are highly resistant to certain diseases and pests, and may possibly pass on some of these characteristics to the scion.

Selected rootstocks affect Pears, Plums and Peaches in similar ways. Besides this, "lack of affinity" between stocks and scions has been found to exist not infrequently. In this case the buds or grafts either fail to grow, or the trees remain weakly and ultimately die out prematurely (Specimens 14—b, c and d, Photographs 14—f, g, j and k).

The fruit grower should accordingly remember some simple rules : not to plant trees except upon selected root stocks ; to make up his mind what character of tree he wants and to ask for trees on stocks suitable to his purpose ; he must not be deceived by " cheap " trees, but must plant only the best.

Further information will be found in the Ministry's Leaflets No. 148 (Planning and Planting a Fruit Plantation) and No. 162 (Propagating Apples, Pears, Plums and Cherries), and in the Published Reports of the Research Station.

Pollination of Fruit Trees.

The Exhibit (Case E) from the **Royal Horticultural Society's Gardens, Wisley, Ripley, Surrey,** while dealing specially with the Pollination of Hardy Fruits, is at the same time of particular interest generally. The effective cross-pollination of the blossoms of most of our hardy fruits is now generally regarded as a vital factor in obtaining good crops (No. 19). Experiments have demonstrated that of the many varieties of " top fruits " (apples, pears, plums and cherries) the majority are quite unable to set good crops, however freely they may blossom, unless pollen of another variety is brought to the stigmas of the flowers. This fact is of the utmost importance in planning an orchard.

Pollination is the transference of the pollen to the stigma (Nos. 1-2). When the stigma receives the pollen from flowers of the same variety it is " self-pollinated " ; when the pollen comes from flowers of another variety it is " cross-pollinated." Stigmas usually become sticky or moist shortly after the blossoms open (No. 9) ; a ripe pollen grain when brought to a stigma which is in this receptive condition germinates and sends out a slender tube which penetrates the style and grows down to the cavity of the ovary (Nos. 2-3). Here it comes in contact with an " ovule." Part of the contents of the pollen grain than fuse with part of the contents of the ovule. This is fertilization, of which seeds and fruits are the result.

If pollen from a tree of the same variety is able to bring about fertilization, that variety is said to be self-fertile. If it fails (as is often the case) it is said to be self-sterile.

Comparatively few of the " top fruits " are self-fertile (No. 13), the majority being only partially so.

Others are quite self-sterile and entirely dependent upon pollen from another variety for good fruit-setting, and even the few self-fertile kinds set better crops when

cross-pollinated. It is of no great importance, for practical purposes, to know the actual degree of self-fertility of each variety, since cross-pollination is likely to induce larger settings of fruit with all. Most of the "small fruits," such as gooseberries, currants, &c., are markedly self-fertile, and with these it is not so essential that provision for cross-pollination be made. Self-fertile plants, however, often require help to transfer the pollen from an anther to the stigma, though the two are close together in the same flower. Although, for example, "small fruits" are self-fertile, they depend on the help of insects. When, as in the case of the "top fruits," the pollen, to produce good crops, must come from another tree, insect help is still more needed. Nuts and mulberries (No. 4) are the only hardy fruits which are pollinated by the wind. This is only in accord with expectations, for the conspicuous flowers, small stigmas, sticky pollen, and scent and nectar of the insect-pollinated flowers contrast with the absence of scent and nectar, the inconspicuous flowers, and dry, light, abundant pollen of the typically wind-pollinated catkin-bearing fruits.

Bees and Other Insects.

Hive bees are frequently looked upon as the most active pollen-carriers among the insects. They are certainly indefatigable and valuable, but by no means the only workers; in fact, the work may possibly be even better done by other insects. Humble bees take a foremost place; they work at least as hard as hive bees, and they work earlier and later, and during good weather and bad. Then there are the different wild bees, mostly belonging to the genus *Andrena,* and the hover flies, as well as midges and various two-winged flies; and although the visits of the latter may be less purposeful than those of the bees there is no doubt that in the aggregate the amount of pollen distributed by them is considerable. These many wild insects are likely to find a home near most orchards and gardens (No. 18), and where the keeping of hive bees cannot be combined with the management of the orchard the work may safely be left to them.

During high winds and rough weather these insects prefer to work small areas, and when planning the orchard it is inadvisable to plant larger blocks than four rows without at least one row of another variety to provide pollen, as (No. 11) it is possible that in larger blocks than this insects may not travel sufficiently far to cross-pollinate the innermost trees.

So far no instances have been discovered among apples or pears where the pollen of one variety fails to cause fruit production in another ; that is, all varieties of apples and pears, so far as is known, are inter-fertile. Among varieties of plums and also of sweet cherries, however, there are, as Mr. Crane has shown at the John Innes Horticultural Institution, a few varieties that will not inter-cross successfully (No. 10).

With these few exceptions it seems that pollen of any one variety is capable of inducing just as good fruit-setting on a given variety of the same kind of fruit as any other.

Choice of Varieties.

The choice of varieties for interplanting therefore, depends almost entirely upon the time of flowering, for it will be obvious that the closer together are the flowering periods of the varieties planted adjacent to one another, the more effective is the cross-pollination likely to be between them (Nos. 6, 7, 8).

Although the number of days a variety remains in flower varies according to the season, and some varieties have normally a slightly longer flowering period than others, the relative order of flowering in any district varies but little each year. To make the charts 6, 7 and 8 a reliable guide to varieties which may be planted together, the effective flowering period of each variety is estimated as from two days before full bloom to seven days after—thus allowing for possible slight variations in times of flowering, unfavourable weather during blossoming, and the like. Between varieties whose effective period of flowering overlaps, cross-pollination should take place in any year. In plantations of apples and pears where cross-pollination is not properly provided for, a useful plan is to top-graft the trees in every fourth row or so with scions from a variety or varieties (No. 20) capable of effecting the desired purpose. Top-grafting plums and cherries is not recommended, and with these it is better to grub and replant with suitable varieties.

When, as is often the case in small gardens, there is only one tree, or when, if more than one, the trees are all of the same variety, it is usually convenient to plant near by another variety having a similar flowering period.*

* The following papers may be consulted : "Pollination in Orchards," Chittenden, F. J., Jour. Roy. Hort. Soc., Vol. XXXVII., p. 350 ; Vol. XXXIX., pp. 366, 615.

Rawes, A. N., Jour. Roy. Hort. Soc., Vol. XLVI., p. 353 ; Vol. XLVII., pp. 8, 15 (with G. F. Wilson).

Chittenden, F. J., Annals of Applied Biology, Vol. I., 1914.

Crane, M. B., Jour. Pomolog. and Hort. Sci., Vol. III., 1923.

THE HEALTH OF THE PLANT.

It stands to reason that it is little use improving plants unless care is taken of their health. Plants have many enemies, but the most difficult to counter are insect and fungus attacks. The exhibit (Cases F and G) of the **Agricultural and Horticultural Research Station of the University of Bristol** affords a useful link between this and the previous section, dealing as it does both with the improvement and the health of plants.

Seedling Stocks of Fruit Trees.

In the exhibit of the East Malling Research Station the use of stocks for the grafting of fruit trees was shown. The stocks there dealt with were produced from cuttings or layers. Case G shows stocks produced from seeds—from cider apple pips. When strong-growing trees are wanted these seedling or "free" stocks are useful, but seeds of most cultivated varieties of fruit do not "breed true," and consequently seedling stocks differ considerably in vigour and other characteristics. Photographs show the three main differences in roots of four-year-old plants, varying from fibrous to coarse roots. These stocks are now being propagated by "stooling" or layering (see the exhibit showing the method employed). It may be mentioned that where propagation by seed is uncertain, what is known as "vegetative" propagation—cuttings, layers, divided plants and so forth—always reproduces the same as the original.

Manuring of Fruit Trees.

The manuring of fruit trees is a matter at present little understood. The effect of the omission of any item of the plant's dietary—nitrogen, potash, phosphorus, calcium and magnesium—is marked in each instance by characteristic features shown in the exhibits (Case G).

Fruit Bud Formation.

The next exhibit illustrates an artificial method of inducing fruit bud formation. Plants collect carbohydrates (sugar, starch, &c.) from the air by means of their leaves. If a ring of bark is removed from a branch, the reserve of carbohydrates is believed to be largely retained in the portion above the ring, with the result that many of the buds in that position are transformed into fruit buds, extension growth being correspondingly restricted.

Two other exhibits (see Case F) may be noticed, before finally passing to the question of plant diseases. The first of these is the cider exhibit which shows the wide variation in vintage quality of different kinds of apples. It includes also pure cultures of the various kinds of yeasts, which play a part in the fermentation of cider, and pure cultures of the various bacteria which produce disorders in cider. Specimens of cider brandy and dried pomace (used as a cattle food), by-products of the cider industry, are also shown.

Cider.

The second is the basket willow exhibit. Only a few of the willows found in this country are suitable for basket making. Specimens of these and others are shown. The four colours of rods at present used by basket makers are shown, together with others at present being tested. An addition to the range of colours would be a stimulus both to manufacturers and to growers. The special pests and diseases of the willow, and the use of the peeled bark for manure are also shown.

Willows.

Passing now to the special question of the health of the plant, we notice the exhibit which deals with "Big Bud" of black currants, which is caused by mites, and "Reversion Disease" of black currants, of which the cause is at present unknown. Methods of recognising the disease are shown. Another exhibit illustrates what is known as "Red Plant" of strawberries. The cause of this disease (otherwise known as "red leg" or "red leaf") was in dispute until last year (1923). The specimens shown exhibit the chief symptoms—the most significant being the bunching which makes the "crown" look more like a cauliflower than part of a strawberry plant. This "cauliflower" appearance has been known for some 30 years, and what has recently been proved is that it and "red plant" are due to the same cause. The cause is a microscopic eelworm,* which in late spring and summer may be found in the buds, later in the year migrating apparently to the bases of the leaves, though even in the winter some may be found in the growing points. Experiments seem to promise a means of killing the eelworm, and the possibility of combating it by cultural methods is also being investigated.

Plant Diseases.

* Eelworms are illustrated in Case U.

Another exhibit deals with canker of apple trees, of which the cause is not an insect but a fungus. This fungus (*Nectria galligena*, Bres.) finds its way into the tissues of the plant through various weak places (pruning wounds, areas affected by other diseases, or cracks in the young woody shoots adjacent to the leaf scars). In isolated cases it may be cured by cutting, but where districts or soils are favourable to the disease only immune varieties of apples should be grown.

Insect Pests: Life Histories.

Exhibits (Case H) from the **Rothamsted Experimental Station** and from the **Ministry's Pathological Laboratory** illustrate the main lines of attack on insect pests. In the Rothamsted Exhibit will be seen the life histories of the Gout Fly of barley and the Aphis or "black fly" of the broad bean. These exemplify the minute knowledge which must be gained about an insect before it can be attacked with any hope of success. The first generation of gout flies appears in May or June and lays eggs mainly on spring barley. On hatching out the grubs (larvæ) attack the shoots and destroy much of the grain. Then they turn into pupæ, from which the second generation of flies emerges, from the beginning of August to the end of September. These lay eggs on couch grass, and on any young wheat and barley they can find; the grubs do not become pupæ until the following spring and give rise to the first generation of next year's flies.

The Bean Aphis (*Aphis rumicis*) starts with the eggs laid in autumn by a fertilised female on a plant which will hold out through the winter (spindle tree, etc.). The eggs hatch in April and the young aphids after 14-20 days become, without fertilisation, wingless mother-aphids, which do not lay eggs but produce several young aphids daily, up to a total of about 50 each. These likewise give birth to young, some of which are winged and fly off to plants such as docks, poppies and beans, reproduction going on all the summer. In autumn some survivors fly off to a winter host, where the females (now fertilised) lay eggs for next year's broods. For the way in which the aphis sucks the life-juice of the plant see the model exhibited by the Pathological Laboratory. It also at the same time injects a damaging saliva. Some varieties of beans suffer less from aphides—it may some day be possible to breed resistant varieties.

Cultural Methods of Control.

The cultural methods of fighting insects cannot well be demonstrated by exhibits. Early sowing of oats or barley often gets the plants well away, too soon for frit fly or gout fly to do them much harm. Suitable manuring, by helping the ear to ripen early, reduces danger from gout fly. Where wheat bulb fly is to be feared, winter wheat should never be sown immediately after a bare fallow or early potatoes.

Natural Method of Control.

Another method of keeping insects in check—which may be called the natural method—is by means of other insects which live or prey upon them. Insects occasionally find their way to countries where their natural enemies do not exist.

Earwigs.

Thus, in New Zealand the common earwig has recently much increased in numbers. In Britain two species of Tachinid flies* live on (or to put it technically "parasitise") earwigs. One species (*Digonochæta setipennis*) lays eggs alongside groups of earwigs. A tiny grub (larva) almost immediately hatches from each egg and bores into an earwig, in which it completes its growth. When it is time to become a pupa it gnaws its way out of the earwig and kills it. Later the pupa becomes a fly, and the cycle is repeated. The other parasite is known as *Rhacodineura antiqua*. It lays its eggs on anything that the earwigs have been feeding upon. When the earwigs return to feed they swallow the eggs. Soon a minute larva hatches out from each egg inside the earwig. This larva behaves very much the same as the other. Unfortunately these useful flies have, in England, an enemy—a small chalcid (*Dibrachys boucheanus*). This lays eggs in the pupæ of the Tachinid flies. So in sending the Tachinids to New Zealand, great care must be taken not to send the Chalcids as well.

Tsetse Fly.

In certain parts of Africa the Tsetse fly is a great trouble. This insect (genus *Glossina*) is a carrier of the micro-organisms (trypanosomes) which cause the fatal "sleeping sickness" in man and "nagana" in domestic animals. In East Africa there is a minute Chalcid (*Syntomosphyrum glossinæ*) which lays its eggs in the puparium of

* Information as to these and other beneficial insects will be found in the Ministry's Miscellaneous Publication No. 37 (Beneficial Insects), on sale at His Majesty's Stationery Office stall, price 4d.

the Tsetse fly. When the larvæ are hatched out they destroy the pupa. In West Africa this Chalcid cannot be found, so supplies of fly puparia containing the parasite were sent from East Africa to Rothamsted that stocks might be bred from them for use in West Africa. Luckily the insect will also attack the puparia of the common blow-fly, so many blow-fly puparia containing the Chalcid parasite have been sent in cool storage to West Africa.

Insecticides.

The remaining exhibit deals with artificial methods of control and shows an apparatus designed at Rothamsted for testing the efficiency of various insecticides under controlled conditions. Likely substances, after passing laboratory tests, are then submitted to further trials in the field. It also illustrates the chemical constituents of a tropical creeper (Derris) the stems and roots of which have valuable insecticidal properties, though these vary widely in different samples.

Spraying.

The exhibit of the **Ministry's Pathological Laboratory (Milton Road, Harpenden)** (Case H) continues the subject of the health of plants. The practice of spraying* is founded upon a knowledge of the manner in which insects live and feed. Reference to the enlarged model of a caterpillar† representing one class of pest shows it to be chewing a leaf with its jaws. War against this class is made by spreading upon their food-plants a poison fatal to them, but harmless to the plants. Such a poison, of which lead arsenate is a type, must be capable of remaining for several days upon the leaves, and, where the latter are waxy or shiny, be mixed with a spreader such as saponin to cause it to spread evenly. Poisons of this nature are known as internal poison insecticides because the insects swallow them with their food.

In contradistinction to this method, poisons coming within a second category are known as contact insecticides because they are sprayed upon the insects themselves and kill them by contact. If attention be now transferred to the enlarged model of a plant-feeding Bug,‡ the reason why the first method would not act is obvious, as it will be seen that

* See the Ministry's Sectional Volume No. 2 (Collected Leaflets on Insect Pests of Fruit Trees), obtainable at H.M. Stationery Office stall, price 10d.

† *Hybernia defoliaria.*

‡ *Lygus pratensis.*

the insect has no jaws, but feeds by means of a proboscis or trunk which it drives below the surface of the leaf in order to suck up the sap from within. To poison the surface of a leaf would therefore be futile. Aphides or "blight" of fruit trees, roses, etc., are well-known examples of sucking insects. The outside covering of an insect is really its skeleton, with the soft parts inside. To kill the creature by spraying it, it is necessary to reach the vital organs comprised by these soft parts, and as an insect, again, differs from the larger animals by breathing through pores along each side of the body instead of through the mouth, death is caused by poison getting into these pores or by blocking them up and causing suffocation.

Nicotine, quassia and paraffin (kerosene) are types of contact insecticides. Both contact and internal poison sprays are always much diluted with water, and the same difficulty that arises in wetting a shiny leaf without the addition of some agent to correct this disability also obtains in wetting the waxy skins of many of the sucking insects, *e.g.*, the well-known Woolly Aphis of the apple.

Reference to the pictures illustrates the need for such a spreading agent in the case of applying an internal poison insecticide to apple leaves, on the one hand, and to the necessity of adding to a contact spray a spreader or wax solvent when dealing with Woolly Aphis, on the other hand.

Finally, it should be added that, given the appropriate spray in correct mixture, the battle is only half won. For the achievement of success in its use, careful and thorough application is necessary. Further reference to the pictures of sprayed apple leaves will show how by careless spraying a good spray mixture may be rendered ineffective, with a consequent loss of time, trouble and money.

Natural Method of Control.

A further exhibit shows a "natural" method of control applied to the Woolly Aphis. Through the kindness of Dr. Marchal, the eminent French entomologist, a minute Chalcid wasp has been imported, which lays its eggs inside the aphides, where the grub is hatched out. It feeds on the interior organs of the aphis, eventually kills it, and changes into a pupa inside the dead body. The pupa at length becomes a Chalcid wasp which emerges through a hole in the skin of the aphis, and the cycle begins again. Colonies of these Chalcids are being installed this season in the chief fruit-growing districts.

The South-Eastern Agricultural College, Wye, Kent, supplies an exhibit consisting of photographs illustrating four alternative methods to spraying with poisons. (1) The first of these consists of spraying lime-wash upon the tree in such a way as to cover the branches to the extreme tip of every twig just before, or just when, the buds are bursting. This spraying coincides very largely with the hatching of the eggs of pests upon the tree, the result being that the majority are smothered.

Other Methods of Control.

(2) The females of winter moths have no wings. The second series shows how advantage is taken of this peculiarity by placing sticky bands around the fruit tree trunks to catch the moths in autumn and winter as they emerge from their chrysalides in the soil and ascend the trees to lay eggs.

(3) Photographs of another form of banding are shown which illustrate the placing in summer of loose sacking round the trunks of apple trees to provide comfortable quarters in which Codling Moth maggots and Apple Blossom weevils may hide, the sacking bands being subsequently burned in winter with their contents.

(4) The final series of photographs shows the employment of poultry in the destruction of pests, in which they are most efficient. Fowls and ducks in orchards will destroy the pupae of Winter Moth, Apple Sawfly, and Pear Midge which are in the ground during winter. In the open fields after harvest they will take great numbers of wireworms, caterpillars and leather-jackets, and, if turned into fields of cabbage, will clear away quantities of Cabbage Moth and other caterpillars ; care should be taken to move the birds after they have exterminated the insects lest they then attack the plants.

On the extreme right of the case is an exhibit, contributed by the **Department of Agricultural Entomology, University of Manchester,** consisting of cases containing specimens illustrating the life-histories of three vegetable pests—the Carrot Fly, the Onion Fly, and the Cabbage Root Fly—the maggots of which do much damage to the plants which give the flies their names. The cases are supplemented by photographs showing enlargements of some of the early stages of the insects, of attacked plots untreated and those treated with

Carrot, Onion and Cabbage Root Flies.

insecticides, and the method of applying tarred discs to the base of cabbage plants to prevent the flies from depositing their eggs.

Magpie Moth, &c.

Pictures on the back and sides of the case represent the Magpie Moth, a pest of gooseberries and currants (controlled by spraying with an internal poison insecticide), the Winter Moth (dealt with in the South-Eastern Agricultural College exhibit), and the Carrot Fly (shown in the Manchester exhibit).

Fungus Pests and Virus Diseases.

Fungus pests and virus diseases of plants are dealt with in another section of the exhibit arranged by the Ministry's Pathological Laboratory.

Silver Leaf

The serious, and for a long time baffling, disease of fruit trees, known as Silver Leaf*, is illustrated by several specimens. This disease, which derives its name from the silvery grey appearance of the leaves of affected trees, chiefly attacks plums, though some varieties of apples may frequently be attacked. Morello cherries and peaches are also often attacked, and the fungus is occasionally found on such plants as laburnum, Portugal laurel, currant bushes and roses, while it sometimes fructifies on stumps of birch and elm. For this disease, the cause of which is a fungus, *Stereum purpureum*, there is no known cure, but natural recovery sometimes occurs in some of the more resistant varieties of plums and apples. Its extension may, to a large extent, be checked by the burning of all dead wood of plums and apples (a proceeding now rendered obligatory by the Silver Leaf Order, 1923), as well as that of other trees on which the fungus is present. All wounds of fruit trees should be dressed with gas tar or a special paint to prevent the entrance of spores of the fungus. The exhibit has been staged by Mr. F. T. Brooks, of the **Botany School, Cambridge University,** who has been conducting the Ministry's research on this disease for some years.

* On this and other fungus diseases of fruit trees, consult the Ministry's Sectional Volume No. 1 (Collected Leaflets on Fungus Pests of Fruit Trees), obtainable at H.M. Stationery Office stall, price 8d.

Another exhibit, staged by the Advisory Mycologist of the **South-Eastern Agricultural College, Wye, Kent**, deals with Bunt or Stinking Smut of Wheat and its prevention by treatment of the seed grain with formalin. This does not interfere with germination, as the traditional use of copper sulphate (bluestone) not infrequently does.*

Bunt or Stinking Smut of Wheat.

A third exhibit illustrates the life history of the fungus which causes American Gooseberry Mildew.† The photographs show the mildew in its white or summer stage as well as in its brown, winter stage. The white, powdery stage is extremely infectious, since millions of spores are widely spread by the wind and other means. At this stage the disease is best combated by spraying with lime-sulphur. At the later or brown stage the tips of all diseased shoots should be cut off and burnt. This should be done as soon as the leaves fall, for if delayed until mid-winter many of the conceptacles containing the winter spores will have fallen to the ground, and from them a fresh attack in the following spring will arise.

American Gooseberry Mildew.

The disease of Red Clover known as Clover-Sickness or Stem-Rot is fairly well known.‡ Two other diseases of Red Clover, viz., Scorch and Violet Felt-Rot, are shown by photographs. The fungus which causes Scorch (*Glœosporium caulivorum*) produces lesions in the stems, and the latter become brittle and break; most of the leaves, being deprived of moisture, dry up and either drop off or are useless for hay. In Violet Felt-Rot (*Rhizoctonia violacea*) the spawn of the fungus mainly affects the roots of the young plant. The root becomes soft and decays away.

Diseases of Red Clover.

The remaining exhibits, prepared by the Advisory Mycologist of the **Department of Agricultural Botany, University of Manchester,** deal with what are known as Virus or Degeneration Diseases of the potato.§ The effects of these insidious maladies are better known than their causes. Research, however, has shown that they are due to one or more viruses,

Potato Degeneration Diseases.

* See the Ministry's Leaflet No. 92.
† See the Ministry's Leaflet No. 195.
‡ See the Ministry's Leaflet No. 271.
§ See the Ministry's Leaflets Nos. 164 and 373.

which are able to pass through the minute pores of certain filters through which ordinary bacteria are incapable of passing, and they may, perhaps, eventually turn out to be ultramicroscopic organisms. The potato plants become infected with these viruses through the agency of sucking insects, such as certain green-flies (aphides), and these have been proved to be transmitters of the diseases. The virus, or infective principle, passes into the tubers, and thus the progeny of an infected plant also carry the disease, re-infection by insects not being necessary. The general results are seen in a dwarfing of the plants, accompanied by changes in the character of the foliage, such as curling and mottling, or in some cases by streaking and shedding of the leaves, while the yield is greatly reduced and the tubers themselves may gradually degenerate and in some cases finally become extinct. By using as "seed" immature tubers from plants grown under cool, northern conditions and only slightly infected, it has been found possible to get comparatively clean crops the following year. In such cases the virus, though present in the over-ground part of the mother plant, apparently does not succeed in reaching the young tubers before they are lifted. There is consequently much in favour of the practice, adopted in some parts of Scotland, of using immature tubers for seed.

Crops under Glass.

The Experimental and Research Station at Cheshunt, which is situated in the heart of the Lea Valley glass-house district, is devoted to the investigation of the many problems connected with the cultivation of crops under glass. The exhibit deals with the control of diseases* and pests (**Case I**).

Fungus Pests.

Leaf-spot or anthracnose of the cucumber is due to a fungus named *Colletotrichum oligochætum*. This may be introduced in infected soil, manure, or water and can live from season to season in rotten woodwork, paper packing, etc. Consequently, proper winter cleansing of infected houses is important.

The tomato suffers from several diseases. "Buck-eye Rot" or "Black Rot" (so called from its appearance) is

* Fuller information may be obtained in "Diseases of Glass-house Plants," by Dr. W. F. Bewley, Director of the Cheshunt Station.

Tomatoes: Fungus Pests.

caused by a fungus, *Phytophthora parasitica*, which is splashed up from the soil in the process of watering and held in a film between the fruits of the bottom trusses. Mulching the soil with straw prevents splashing, but, if once the fungus gets a hold, diseased fruits must be removed at once, as it quickly works along to the main stem and causes the death of the whole plant.

A root-rot may be caused by a fungus known as *Colletotrichum tabificum*. It may be identified by the presence of minute black bodies on the wood of the roots and lower portion of the stem. Steam sterilisation of the soil destroys the germs, while good cultivation, by producing sturdy plants, helps to keep the disease at bay.

Foot-rot is caused by a number of different fungi, mainly belonging to the genus *Phytophthora*, which are spread by infected soil, water, seedboxes and pots. Sterilising the soil and boxes by heat or formaldehyde and cleansing the water supply are the best preventives, but some growers prefer to use the fungicide known as "Cheshunt Compound," devised as the result of investigations at the station. This is useful in an emergency, but is not suitable for continued application.

In this country "Sleepy disease" is caused mainly by a fungus, *Verticillium albo-atrum*, which thrives at a low soil temperature and does most damage in spring and autumn. When this fungus is found to be present it may be combated by raising the temperature above 77°F. Shading and light overhead watering rather than watering of the roots are also useful, while fresh soil placed at the base of the plants will encourage the formation of new roots.

Stem-rot is caused by another fungus—a species of *Botrytis*. This fungus enters the plant very easily by way of any dying or dead tissue. Thus, careless pruning, which leaves dying leaf bases, is favourable to it. Unwanted leaves should be cut clean, close to the main stem; such a wound rapidly heals and offers no foothold for the spores. The disease is heralded by a browning of the tissues in the stem. This occurs ahead of the fungus. If, therefore, the brown portions are removed and the wound painted with a strong solution of copper sulphate the disease can be arrested. While careful trimming and regulation of humidity will do much to control the disease, it may, in bad cases, be necessary to spray the lower portions of the plants with a 2 per cent. solution of calcium bisulphite.

Tomatoes: Insect Pests.

The main insect pests of the tomato, grown under glass, are the Tomato Moth (*Hadena oleracea*, L.) and the White Fly (*Asterochiton vaporariorum*, Westw.). As already explained, the main requisite for the successful control of insects, is a knowledge of their life-histories. These have been studied at the station and are fully shown on the exhibits, and instructions for control are given on a printed card.

Red Spider, while more partial to cucumbers, has, of late, done much damage to tomatoes. It lives through the winter and many generations come into existence during the summer. A female lays as many as 90 eggs, from each of which in 4 to 5 days a larva is hatched with three pairs of legs. It feeds for about 2 days and then takes a similar time to moult, appearing then with 4 pairs of legs. A similar third stage is then passed through, and the full-grown spider appears. Spraying the empty houses at the end of the season with an emulsion of pale straw cresylic acid and potash soft soap has been found effective. Plants cannot be grown for 14 days after use of this spray. A summer spray of flour and sulphur is also used.

The Cucumber House Woodlouse (*Armadillidium speyeri*, Jackson) gnaws the bark and eats the young leaves of cucumber plants. It lives for at least three years and breeds annually. In May the female develops a pouch under the thorax in which the eggs—some 50—are carried and in which they hatch, the young, on hatching, being minute white objects but resembling the mature woodlouse. There is only one generation in a year. The young soon moult and become adult in the following year. Though confined to cucumber houses, these woodlice will attack tomato seedlings propagated therein. They may be trapped with mangolds or red beets cut in half and placed face downwards on the borders. At the end of the season a somewhat similar spray to that used for Red Spider is effective.

Two flies, or rather their grubs (*Pnyxia scabiei*, Hopk., and *Plastosciara perniciosa*, Edwards) enter the tap root of the cucumber, killing it in a week. This they do when the surrounding soil is not moist enough. They cannot, however, stand excessive moisture and can be completely controlled by heavy watering.

HORTICULTURE AND FARMING.

Glass-Houses.

In Case J three model glass-houses are shown. These represent Carnation, Cucumber and Tomato houses as used by British growers for commercial cultivation.

Fruit and Allotments.

The Ministry's Horticulture Division exhibits (Case L) typical specimens of fruit grown in England in 1923. Full descriptions of the principal commercial varieties of fruit appear in the Ministry's leaflets.*

The Model Allotment Garden (Case K) shows on a scale of one-twelfth natural size the arrangement and cropping of an ordinary 10-rod allotment, as recommended by the Ministry.†

The Farm and Farm Machinery.

The Model Power Farm‡ (Case M) exhibited by the **Ministry's Machinery Branch** is designed to illustrate the use of mechanical power for field operations,§ the lay-out and equipment of farm buildings, and the use of electricity on the farm.

Ploughing by steam tackle—which is usually done by contract, the contractor travelling from farm to farm—has been in vogue for over half a century. Its advantages are the efficiency of the work, as shown by resulting crops, and the rapidity with which it is performed.

The tractor came much into use during the late war, since when it has been considerably improved. It is shown in many operations, for which it is admirably suited. In ploughing, one man with a tractor can usually do at least twice as much work as with a horse-plough.

* Reference should be made to the following: Leaflets No. 134 (Profitable Apples for Market), No. 347 (Profitable Pears for Market), No. 346 (Gooseberries), No. 350 (Profitable Plums and Damsons). These leaflets, together with others dealing with the cultivation, marketing and preservation of fruit, may also be obtained in one volume (Sectional Volume No. 4), price 1s. 6d., at H.M. Stationery Office stall.

† See Leaflet No. 315.

‡ The Model has been constructed and erected by the Leeds Model Co., Hunslet, Leeds.

§ Owing to lack of space, the fields shown are much smaller than they should be in comparison with the machinery and farm buildings.

The tractor is a useful machine for the work of sub-soiling, for breaking up the solid stratum or "hard pan"—sometimes as much as 10 in. thick—which often exists below the top soil, blocking the passage of water and air and impairing fertility. "Sub-soiling" has been practised for at least a century, but without sufficient distinction between two processes, true sub-soiling, or breaking of the under soil, and "deep-ploughing," which brings the sub-soil to the surface. In the first year (1923) of trials undertaken by the Ministry every sub-soiled plot has given an increased yield, more than repaying the extra cost of sub-soiling. The effect of the one operation promises to last some time.*

Mowing and Harvesting.

The tractor is also shown drawing two mowing machines; trials in 1922 proved this method to be very economical.† A hay loader may also be drawn by a tractor, the speed with which the hay is gathered being of value in bad weather. The use of the tractor with one binder, which is also shown, is scarcely a saving of money, for the reason that the tractor, without its full load, is wasting power. It should be drawing two binders. The draw-bar pull for two binders is well within the capacity of the tractor. In large fields a tractor with two binders probably saves about 20 per cent. in cost. The tractor is also used in many other field operations, such as cultivating, harrowing and drilling.

Mole Ploughing and Tile Draining.

A tractor is also shown with a mole-plough, an implement used for driving underground "moles" or drains, in heavy clay soils. This is naturally much cheaper than laying down tile drains, as it costs but a few shillings per acre, and the drains or "moles" should last for many years. The more expensive but very remunerative use of tile drains is illustrated. Properly installed, they should increase the value of the land by the amount of their cost, and often pay for themselves, by increased yields, in a few years. The exhibit shows drained and undrained plots under hay. On the latter, the stunted appearance, the rushes and rank growth should be noted.

* See the Ministry's Journal, February, 1924.

† See the Ministry's Journal, March, 1923.

Passing now to the Model Farm Buildings, it must be explained that in planning a farm, the main objects are light, ventilation and sanitation. Care in grouping the buildings to avoid unnecessary work is also important. The best type of farmstead is usually rectangular, forming an open yard at the back and to the side of the farmhouse. Buildings of similar uses should be grouped together —tool house, machine shed and garage, for instance, and in the same way, granary, machinery barn, cattle sheds and silo for convenience of feeding. The exhibit shows a modern type of farmhouse with wireless* to receive weather reports, telephone connecting with all buildings, electric lighting and heating.

Farm Buildings.

Modern machinery driven by an electric motor operates the Granary and Machinery Barn. Cattle-sheds and Dairy† are factories of human food. Too much care cannot be spent in planning or in keeping them clean or healthy. The cattle-sheds run north and south, to secure as much sunlight on the stalls as possible. Ventilation, drainage and cleanliness need most careful consideration. The stall fittings are of steel, and the mangers and floors of concrete. The Machine Shed provides proper accommodation for the costly modern implements. On the Power House is shown a model windmill for generating electricity. This model, kindly supplied by Messrs. Telford, Grier and McKay, of Glasgow, is of the " Airolite " type, which has proved very efficient even in light winds, and resists the severest storms. Storage batteries are installed, and sufficient electricity can be generated for power, lighting and heating. The possibilities of the generation of electricity by air-power are at present being investigated by the Ministry. In the Rickyard a thrashing machine, operated by a tractor, is shown. The exhibit also illustrates a new method, which the Ministry has recently investigated, of drying crops by artificial means. The stack is constructed round a central chamber and air driven through it with a fan.‡ The Silo is an indispensable adjunct of the modern farm, preserving green fodder in a succulent condition. The model,

* See the Ministry's Leaflet No. A.119 T.G. (The Weather and the Farmer).

† No Dairy is shown—a real working dairy is exhibited by the National Milk Publicity Council in an adjoining building. (See p. 48).

‡ See the Ministry's Journal, March, 1924, p. 1128 : Artificial Drying of Crops.

which has been kindly provided by the George H. Gascoigne Co., 27, Market Place, Reading, represents a metal silo, approximately 18 ft. in diameter and 40 ft. high to eaves.* Concrete and wood are also used in the construction of silos. The silo is charged by means of a cutter, which cuts the forage, and a blower elevator which loads the cut forage into the silo. The model cutter and blower are furnished by Messrs. E. H. Bentall, of Maldon, Essex. In the Barnyard will be noticed the tramway tracks, on which run trolleys for conveyance of food or manure.

* Various other sizes are available.

IMPROVEMENT OF ANIMALS.

The earth is Nature's main storehouse of raw material. In subduing that raw material to his use man has two chief servants, the plant and the animal. We have already seen something of his efforts to improve and safeguard the plant. How has he proceeded with the animal? He has studied its breeding in some form or other ever since, winning his own freedom from savagery, he learnt to tame the animal of the wild. Only more or less recently, however, has science, and notably Mendel's discovery, given him a real basis on which to work. Animal breeding is not a subject which lends itself so well to popular exposition as the breeding of plants; the aspects here presented, though of considerable importance, are necessarily only fragmentary.

Sex-Linked Inheritance in Poultry.

The exhibit (Case N) from the **Department of Genetics, University of Cambridge,** illustrates a phenomenon, frequently met with in poultry, known as sex-linked inheritance. Certain characters are transmitted by the hen to her male offspring only. Silver in the plumage, as opposed to gold, is one of these. When a silver hen is mated with a gold cock, the male offspring alone are silver, while all the female offspring are gold. The difference can be seen in the chicks in the ground colour of the down. This is of importance to the poultry-keeper as it affords a sure guide to the sexes of chickens immediately they are hatched. All breeds of fowls are either silver or gold, though this is not evident when the plumage is either fully black or fully white. Consequently a number of crosses may be made on this plan. Five examples are shown. The difference of colour is most clearly seen where the down is light—for instance, where a light silver (Light Sussex hen) or a light gold (Buff Orpington cock) has been used. It is fairly clear in the Light Dorking X Brown Leghorn cross, least obvious in the cross Silver Campine X Brown Leghorn. In the last case, however, it is sufficiently evident at the sides of the head and neck. The characters of barred and black also exhibit sex-linked inheritance. A barred hen crossed with a black cock gives only barred sons and black daughters. In the down of the chick the barred plumage is foreshadowed by a light patch on the back of the head. The exhibit shows a cross between a Barred Rock hen and a Black Leghorn cock.

For further information those interested are referred to "Heredity in Poultry," by R. C. Punnett, of which a copy is exhibited.

Sex in Poultry and Goats.

An exhibit (Case O) from the **Animal Breeding Research Department of the University of Edinburgh** deals also with poultry, and illustrates the subject of sex in fowls. The exhibit, which is of high technical, though possibly of less general, interest, is sufficiently explained by the labels attached. The same applies to another exhibit in the same case which deals with developmental intersexuality in the domesticated goat.

Improvement of Wool and Mutton Sheep.

Another exhibit from the same source deals with the improvement of wool by crossing. The wool of British sheep, especially of the mountain breeds, is not as good as could be wished, and efforts are being made by various methods, such as selection and crossing, to obtain finer and more valuable wools. At present an experiment is being tried of crossing the Scottish Blackface Mountain sheep with Southdowns. It is thus hoped to create a breed as hardy as the Blackface and at the same time producing equally good mutton and finer wool. For the purpose of this experiment, which must, of course, last many years, a thorough knowledge is required of the nature and composition of the fleeces of the parent breeds and their progeny. Samples of wool and microphotographs of the various fibres composing the fleeces are shown.

Peruvian Merinos.

Samples are also shown of the wool of the Peruvian Merino sheep. These animals live at a high altitude, exposed to great extremes of temperature, and produce a wool of comparatively good quality. It has been suggested that they might be used for improving the wool of British mountain breeds, without lessening their hardiness. As the result of a scheme put forward by the Joint Committee on Sheep Breeding,* a number of Peruvian Merino rams have been imported (along with a small foundation stock of ewes) and sold to breeders for crossing with British breeds. Microscopic examination is also being made, in view of further research, of the wool of all the more important British breeds. The microphotographs shown give an idea of the range in size of fibre.

* British Research Asscciation for the Woollen and Worsted Industries.

The Department is also collaborating in a scheme for the improvement of the wool of Welsh Mountain sheep put forward by the University College of North Wales, Bangor.

Welsh Mountain Sheep.

For the purpose of this scheme minute details are being collected, not only as to the various fibres composing the fleeces, but as to the development of the fleece from birth to maturity. There is also need to know how individual fleeces vary from year to year and under different conditions of environment. (See exhibits showing the different kinds of fibres separated out and the microphotographs of sections of these fibres.) From the manufacturer's point of view the main defect in Welsh wool is the occurrence of " kemp " and " red kemp." Very coarse hair only occurs at all in some individuals, and when it does occur it is practically restricted to small and unimportant areas of the body. Kemp, often described as " dead hair," consists of very coarse, short, brittle fibres, often much flattened and containing weak spots or breaks along their length. Kemp is of annual growth as opposed to the other fibres, whose growth is continuous, the fibres merely becoming thinner at the time of the " rise " in the wool. " Red kemp " consists of rather similar, but pigmented, fibres. There is little doubt that kemp could be very much reduced by selection ; in every Welsh flock there is enormous variation, some individuals having coats practically free from it, while the coats of others are full of it. As a matter of fact, in some flocks of Black Welsh Mountain sheep kemp has been practically eliminated by selection. This, however, is not the real difficulty.

The breeder (as opposed to the manufacturer) favours kemp. He thinks that it has something to do with hardiness and that the kemp-free sheep has a poor covering at birth. The breeder looks for (1) a good covering at birth and (2) a good " tight " wet-resisting fleece in the adult sheep, and (3), while he may want the wool improved, he certainly does not want the mutton qualities and the suitability of the sheep for its surroundings to suffer. Now, as regards the covering at birth, it was found that the coats of Welsh lambs fall into three sharply defined types : (1) Thick coat all over, (2) fine curling wool on forepart of body only, (3) a fine coat all over (see the exhibit). The breeders say that (2) and (3) are not suitable for extreme conditions. Whether this is so or not can only be tested in a really bad spring.

Now, the chief problem is to make the breeder's requirements and those of the manufacturer meet. To this end

it is necessary to examine a great many sheep and to determine four points in the case of each : (1) What is the covering at birth, (2) in what precise particulars does the fleece of the adult sheep meet the requirements of the breeder, (3) in what precise particulars does it meet the requirements of the manufacturer, and (4) what amount of kemp is present. This is determined for two samples from each fleece (see exhibits), from the best part the shoulder and from the worst—the britch or hind flank. To these four points may be added in some cases a description (5) of the mutton qualities of the sheep.

This work done, and some other points considered, it will be possible to go on to the question of the inheritance of fleece characters and their possible correlation with other important qualities.

Milk Production.

We may continue the subject of animal products and their improvement by turning to the Exhibit (Cases R and S) of the **National Institute for Research in Dairying (University College, Reading.)*** Milk is the most indispensable of foods ; everything connected with its production deserves the minutest study. The cows must be fed ; this involves careful management and well-considered cropping of the dairy farm, as well as knowledge and business skill in the selection and purchase of manufactured and imported foods to supplement the home supply ; the ration must be so compounded as to produce a wholesome milk ; the milking of the cows and the handling of the milk must be both expeditious and cleanly. To all this must be added wisdom in selection and breeding, and care in the housing of the herd.

For this the dairy farmer receives a proportion of the price paid by the public. One means whereby the cost of milk may be ultimately reduced is the introduction of better and more economical methods. Such methods will only be discovered by a close study of every detail involved in milk production. Some aspects of this kind of study are illustrated by charts (Case R). One set of these shows the effect of calving in different months of the year on the annual milk yields. The yield of milk from cows calving in different months of the year varies considerably, but the amount of the variation in one district differs from that found in another. The charts illustrate the variation found by a study of records from herds in the Berkshire, Buckinghamshire and Oxfordshire area. In this area cows calving

*The Institute is situated at Shinfield, near Reading.

from May to September give comparatively poor yields. This fact must be considered when comparing the cost of production of winter and summer milk.* Another set of charts shows the effect on three farms of different methods of management on the milk yield of cows of different ages. There is no doubt that management does affect the yield of milk in various ways. This is a question that requires further study : meanwhile it is evident that management is an influential factor, which must be considered in estimating the true value of milk records, whether of individual cows or of herds.

Milk Products : Stilton Cheese.

The exhibits (Case R) show that the outside of a Stilton cheese should have a clean crinkly coat, while the cut surface should show a creamy colour with a close net-work of blue veining. It is not easy to manufacture first-class Stilton, one of the most serious difficulties being the appearance, towards the end of ripening, of discoloured patches. From the pictures and specimen it will be seen that the discoloration is mainly yellow ; pink, brown and black patches may also occur. A few years ago the loss to the industry from this cause rendered investigation necessary. A visit to a " Stilton " district revealed conditions which are shown by photographs and specimens. As a rule the cows were dirty, the cowsheds dark, dirty and unventilated, and water supplies poor. There was, in fact, every chance for bacterial contamination. A large number of micro-organisms were isolated from samples of the water, the milk and the cheese. Some of these when cultivated artificially produced discoloured patches (see the plates exhibited), but not when cultivated on acid media. The fact that the fault only appears when the cheese is almost ripe suggested that the organisms responsible acted, not on substances originally present in the cheese, but upon substances produced during the ripening process. The series of tubes exhibited show that this was actually the case. Tyrosine and tryptophane are two substances in ripe Stilton cheese, and are produced by the process of ripening from the casein present in the original milk. Varying quantities of acid and alkali were added to solutions of these substances, which were then sterilised and inoculated with cultures of the organisms under consideration. The series of test tubes show the colours which are produced under these conditions, and demonstrate that

*There are physiological difficulties in regulating the time of calving. These are illustrated in an exhibit, of special interest to experts, shown by the School of Agriculture, University of Cambridge (Case C).

the colour-producing properties of the organisms are limited by excessive acidity and alkalinity.

Next the experiment was tried of introducing these organisms into milk which was made into Stilton cheese. The pieces of the resulting cheese exhibited show that the fault, as suspected, was due to deleterious organisms. None of the discolouring organisms are present in the udder of a healthy cow, and must therefore find their way into the milk or cheese during its handling and manufacture. The remedy which suggested itself was the production of acidity by the addition of "Starter" (a culture of organisms producing Lactic Acid). How this prevents the growth of the discolouring organisms is shown by the plate on which cultures both of "Starter" and of the discolouring organisms were made. The organisms show good growth at a distance from the "Starter," but none in its immediate neighbourhood. This method has proved very successful, but care must be taken to avoid excessive acidity, which might alter the nature or flavour of the resulting cheese. To remove the fault altogether will require a fuller knowledge of the conditions necessary for the making and ripening of good Stilton cheese.

Sweetened condensed Milk: Blown tins.

The "blowing" of tins of sweetened condensed milk is a source of serious loss to the milk industry. One cause of this trouble has been found to be the presence of yeasts in the finished product. Cultures of these yeasts are shown in the tubes, and drawings on the chart. They are capable of fermenting solutions of cane sugar even in high concentrations. These yeasts have been inoculated into sound tins of condensed milk, with the result that the tins exhibited are all "blown" and one has burst. The glass jars show what has been happening inside the tins, that is to say, fermentation with production of gas. These organisms are not found in the milk as it comes from the cow's udder, but their presence is due to the fact that the milk has become contaminated at some stage of its handling before it is finally sealed up in the tins. This fault could be eliminated by a more careful manipulation of the milk, and thus a great source of loss to the industry could be avoided.

Cheese Mites.

Cheeses are attacked by four kinds of mites, which cause most damage to the unpressed, ungreased cheeses like the Stilton and Wensleydale.

All cheese mites arise from eggs laid in large numbers by the adult females. The eggs hatch into six-legged larvæ which moult three times, acquire a fourth pair of legs at the second moult, and become full grown males or females in from three to four weeks. In one species of mite there is a special stage adapted for distribution ; this stage possesses suckers for attaching itself to flies, moths and other moving creatures. The adults are long-lived and can endure long periods of fasting. They breed with great rapidity.

The following rules should be observed :—

1. Thoroughly cleanse utensils, shelves, walls and floors, especially corners and crevices where mites can hide ; 2. Remove old infested cheeses from the cheese room ; 3. Use movable shelves ; 4. Net the windows to keep out flies and other insects.

When cheeses have been attacked they should be brushed daily and the mite dust burnt and the cheese rooms should be fumigated with carbon bisulphide according to the following directions : Use 1 lb. of commercial bisulphide for every 250 cubic feet of space. Pour the liquid into shallow vessels placed as high as possible. Then lock the room for 24 hours, after which open up and air. The bisulphide vaporises, and being heavy, sinks over the cheeses beneath. Repeat twice at intervals of 10 days.

In connection with milk and its products attention is called to the **National Milk Publicity Council's Dairy Exhibit**, which will be found in a building close by.

Model Dairy.

Here will be seen an up-to-date cowshed, with a small herd of British Friesian cows. All the processes involved in the handling—cooling, bottling, pasteurisation, etc.—of milk may be seen in operation. In the working dairy the manufacture of various cheeses, etc., may be witnessed. This exhibit has been arranged by the National Federation of Dairymen's Associations. The machinery, by Messrs. Enocks, is all of English manufacture.

Case S illustrates the value of milk as food and indicates the sources from which the food energy is derived.

Milk : Sources of Value as Food.

The soil has been described as " Nature's storehouse of raw material," but Nature has other stores. The exhibit on the " Soil " explained the plant's need for water, air and warmth. The constituents of the soil, the carbonic acid gas of the air, and the water

in the leaves of the green plant, fix and store the energy which comes from the sun. This exhibit illustrates this process in the case of starch formation which takes place only in those parts of the green leaf which are exposed to direct sunshine.

Liquid Sunshine.

The cow eating the green grass transforms some of this sunshine into milk. The fact that the energy which makes the food value of milk is indirectly derived from the sun's rays, suggests that milk itself may be aptly described as liquid sunshine. Sunshine, as we know, may be split up, as in the rainbow, into the different colours which compose it.

Composition of Milk.

The exhibit shows how milk, too, may be divided into its constituent parts in the dairy and in the chemical laboratory. In the dairy milk may be deprived of the water which it contains, one gallon of milk yielding 1 lb. $4\frac{1}{2}$ oz. of dried milk solids. The butter maker obtains about $6\frac{3}{4}$ oz. of butter from a gallon of milk, sometimes drying the remaining separated milk or the butter milk, but frequently using these valuable by-products as food for pigs. The cheese maker recovers casein and most of the fat in the form of the pound of cheese which he gets from a gallon of milk, the other constituents, as shown, remaining in the whey. Whey is in itself a valuable product, but satisfactory methods for utilising it have still to be developed.

The chemist carries the analysis still further, and reveals milk as a most complicated liquid. The exhibit shows the six chief components as extracted from a gallon of milk, and the proportions in which they are distributed among the products of the cheese and butter maker. There are also exhibited samples of substances which the chemist has isolated by still further breaking down these six chief constituents.

The casein and albumen are the flesh formers—complicated substances composed of all those links (amino acids) which can be reassembled in the body of the suckling animal to make its flesh, muscle and organs. Samples are exhibited of fatty acids which have been separated from the milk fat. The ash—i.e., the residue left after burning the milk—contains many earthy substances, represented by samples of phosphates, lime, etc. These

are bone formers. The chemist can also demonstrate the presence of certain enzymes in milk. Peroxidase tests are exhibited.

An important fact to be remembered is that milk is not a simple mixture of these separate products. Casein, for example, is associated with a very delicately balanced proportion of the lime of the ash. This gives to all milk, whether of the cow or other mammal, the property which it possesses of forming a curd in the stomach of the young animal.

Vitamins.

Further discoveries of the nature of milk have been made through feeding experiments on small animals. These experiments show that if the purified constituents of milk—fat, casein, sugar and ash—are put together, the compound will neither support life nor promote growth.

This fact has led to the discovery of a group of substances called Vitamins or Accessory Food Factors. These cannot at present be extracted and exhibited, but have been proved by experiment to be absolutely indispensable to life.

There is a Vitamin in butter fat which promotes growth, and which is studied by feeding the butter fat to experimental rats, kept on a diet otherwise deficient in this vitamin.

Besides this growth-promoting fat-soluble factor (Vitamin A), there is another which is concerned with the formation of bone. Ribs of pigs are exhibited showing swellings caused by a lack of this factor. The leg of a pig is also shown, the sores on which are a sign of scurvy, produced in this case by a lack of Vitamin C. The presence or absence of these important factors in milk and milk products has been studied at this Institute by feeding them to pigs. Photographs of results are exhibited.

Charts are also shown of the results of the most recent work in which butter obtained from the milk of stall-fed cows has been compared with that from grass-fed cows. Two models of rats are also exhibited. In front of one is shown the size of a piece of yellow summer butter which kept the rat in condition and maintained its growth for a week. Ten times as much white butter from the milk of stall-fed cows was required to produce the same result in winter.

There has also been commenced at the Institute a study of the relative values of summer and winter foods in respect of the growth-promoting and other accessory factors which they contain. Seeds hay is compared with meadow hay, and mangolds have been tested by feeding them to rats as well as by examining the butter made from the milk of winter-fed cows.

Summer and Winter Foods.

Even in winter time, when there may be no fresh food to be had, and the cows are kept in their stalls, there is a store of sunshine energy to be found in the seeds, roots and stems of plants, and in the silage which has been preserved for winter feeding. The store of the accessory factors is, however, more restricted, and our winter feeding should be revised to ensure the small though necessary supply of these recently recognised substances.

FERTILITY OF DOMESTIC ANIMALS.

An exhibit (Case Q) from the **School of Agriculture, University of Cambridge,** deals with Fertility and Sterility in Domestic Animals. The exhibit is one which deserves special attention from all who are concerned in the breeding and raising of farm stock, or who are interested in the study of animal reproduction. A description may be obtained on application to the Officer in Charge.

FEEDING OF ANIMALS.

The National Institute for Research in Dairying exhibited, as an important side-line of its work, some results of research in pig feeding. The question of the feeding of domestic animals is of the highest importance, and centres on the problem of how to obtain the highest efficiency at the smallest cost.

The exhibit (Screen P) shown by the **Rowett Research Institute, Bucksburn, Aberdeen,** illustrates some of the methods used and results obtained in the investigation of such feeding problems. This is one of our youngest research institutes. Like other similar research institutes, it is mainly supported by the State, but it has received important private donations, including the initial benefaction of Dr. John Quiller Rowett, from whom it takes its name.

The buildings (Photographs 8 and 12) were opened on the 12th September, 1922, by Her Majesty Queen Mary. The main building consists chiefly of laboratories, where research in the physiology, biochemistry (Photograph 3) and pathology of nutrition is carried on. In the experimental farm buildings feeding experiments on small groups of animals are conducted (Photograph 4). A new department, the Reid Library, has recently been established by special benefaction. It is hoped to establish an Experimental Stock Farm, where the results of investigations can be tested and demonstrated on a commercial scale, with a view to their introduction in farming practice.

Buildings.

One of the main lines of investigation at the Institute has been the Mineral Requirements of Animals, and the influence of the non-mineral part of the food on the assimilation of minerals. This question is being investigated partly by Metabolism experiments, and partly by feeding experiments. Photographs 5 and 6 show cages for metabolism experiments on pigs. The cages are devised so that a complete daily collection of urine and faeces can be made. By analysis of the food, and of the urine and faeces, it is possible in each case to determine how much of each mineral is retained.

Mineral Requirements of Animals.

The results of imperfect assimilation of minerals are shown in sheep in Photograph 15 (Ram with Rickets), and in pigs in Photograph 18 (Pig with Rickets). Photograph 19 shows the influence of the addition of mineral matter to the diet of the pig, and Photograph 16 the influence of the addition of cod liver oil and minerals to the diet of the sheep. Chart 9 shows the influence of oil in increasing the assimilation of calcium and phosphorus from the intestine in pigs. Photographs, &c., 10-14, show the effect on young pigs of deficiency of iron in the diet of sows. Photograph 14 shows a normal pig 14 weeks old, compared with two pigs, 22 weeks old, which are suffering from deficiency of iron. Photograph 17 shows the effect of the mineral content of food on the growth of bone in kids.

Photographs 1 and 2, and Chart 7, illustrate the nature of work done to determine the energy requirements of animals, the influence of work and external temperature on these requirements, and the net energy, or real energy value of different rations. The method used at the Institute is the Indirect Method of Calorimetry. The expired air of the animal is

Energy Value of Foods.

collected in rubber bags, measured and analysed. From the consumption of oxygen and production of carbon dioxide so measured it is possible to determine by calculation the amount of energy or heat produced in a given time. In the Direct Method of Calorimetry (in use at the **Animal Nutrition Institute, University of Cambridge**) the heat output is measured directly.

THE HEALTH OF ANIMALS.

Diseases of Animals.

The **Ministry's Veterinary Laboratory, Newhaw, Weybridge,** shows, in Case T, a number of specimens illustrating various diseases to which domestic animals are subject. These are adequately described by the labels attached.* In the next case the **Animals Diseases Research Association, 83, Buccleuch Street, Glasgow,** shows photographs and specimens. Of these, Nos. 1-5 illustrate bacterial diseases.

Bacterial Diseases.

No. 1 shows the lesion in the fourth stomach of a sheep which was killed while suffering from *Braxy*. The lesion is the point of entrance of the bacterium into the system, where it multiplies and causes death in from 12 to 24 hours. Braxy in the affected areas may cause the death of 25 to 50 per cent. of all sheep in their first winter of life. Vaccination to prevent this disease is now practised on an extensive scale.

Braxy Investigation.

The braxy investigation was commenced in 1918, the general plan being to deal only with live affected animals which were to be killed after a thorough clinical examination had established the diagnosis as correct. Each animal was then to be subjected to a careful post-mortem examination in an endeavour to find any changes, visible to the naked eye, which might be present in the body to account for the symptoms displayed during life. Any organs showing changes were then to be prepared for microscopic examination to find out precisely what was going on in the tissues as a clue to the nature of the causal agent. Having determined the probable nature of the causal agent by these methods, endeavours were to be made to isolate it and subject it to a minute study with the object of discovering a satisfactory means of prevention which could be utilised upon a large scale in the field for the benefit of the agriculturist. Elaborate precautions were taken at every stage of the investigation to guard against all possible sources of error in arriving at conclusions.

* Further information will be found in the Ministry's Sectional Volume No. 5 (Collected Leaflets on Diseases of Animals), obtainable at H.M. Stationery Office stall, price 1s.

The investigation proceeded entirely according to plan. Photograph ii in the braxy series shows the dark area of inflammation which was found in the fourth stomach of the thirty sheep which were obtained alive for investigation purposes. Braxy sheep are rarely seen alive, the vast majority being found dead on the pastures. It was therefore very remarkable that as many as thirty were obtained alive and this speaks well for the wholehearted co-operation of the flockmasters with the scientists. Photographs iii and iv show the microscopic appearances which were found to be constant in the wall of the stomach, these showing that the body cells were endeavouring to defend the body against some invading bacterium and that the body tissues were being destroyed by the invader. Photographs v and vi show how a higher power of the microscope revealed the invading bacilli in the wall of the stomach.

A bacteriological investigation resulted in the isolation of the causal bacillus, and Illustration vii shows a painting of test-tubes containing culture media in which the braxy bacillus is growing in pure culture. It was decided after a detailed study of the braxy bacillus to endeavour to immunise healthy sheep by inoculating them with the toxin (poison) of the germ, the idea being to stimulate their systems to produce their own anti-toxin in sufficient amount to protect them against natural infection. Photographs viii, ix, and x illustrate the method employed in making this toxin.

Extensive field trials with this method of inoculation have been undertaken, and the death-rate in inoculated animals has been found to be reduced to one-quarter of what it is in those uninoculated. Further than this, the reduction in death-rate enables the sheep (hoggs) in many cases to be wintered at home, thereby saving the sum of 15s. or £1 per head as the cost of wintering them in healthy districts whither they were sent annually in large numbers and for long distances by steamer, rail, and road. In the braxy season of 1923-24 some 40,000 sheep were inoculated against braxy by this method.

The investigation has revealed braxy to be a specific disease caused by a bacterium which lives in the soil and gains entrance into the alimentary system of all sheep. It only sets up disease when for some reason or another (a common reason is the filling of the stomach with frosted grass) the tone of the stomach is lowered and the stomach wall tissue is weakened and unable to resist attack. The disease has been shown to be one and the same wherever it occurs in Great Britain or Ireland or in other parts of the world.

No. 2 shows the heart of a pig which died of *Swine Erysipelas*, a disease causing serious losses in several parts of Britain. The "vegetations" on the valves of the heart are usually the cause of sudden death of the pig by reason of their breaking off into the blood-stream and plugging up important arteries. A highly efficient means of preventive vaccination has been brought into use.

No. 3 shows a portion of a horse's lung affected with *Tuberculosis* of the bovine variety. Tuberculosis, while very common in bovines, is comparatively rare in equines.

No. 4 shows the nasal septum of a horse affected with *Glanders*, a very serious disease of equines, and one which is communicable very readily to human beings. By utilising the valuable diagnostic agent known as mallein the veterinary profession has been enabled to stamp out this serious disease from Britain, and by the same means its reimportation will be prevented in the future.

No. 5 shows the ulcerations in the young lamb's intestine in *Lamb Dysentery*, a very serious disease of young lambs in the south of Scotland and north of England. In the affected areas about 35 per cent. of lambs are lost annually before they are two weeks old. This disease has been the subject of much investigation, and research work is still in progress. The trouble is spreading every year over wider areas.

Lamb Dysentery Investigation.

Very much the same plan of investigation was pursued with regard to lamb dysentery as has been described for braxy. Here, too, an essential feature of the work was field investigation in order to secure live affected lambs which could be killed for investigation purposes.

Photographs i and ii show the nature of the country in the south of Scotland and north of England where lamb dysentery is rife. Photograph iii shows a microscope section through the ulcers in the wall of the bowel, which are so characteristic of this disease. Photograph iv shows a small portion of such an ulcer under a very high magnification, demonstrating bacilli in the tissues of the ulcer.

The investigation has shown lamb dysentery to be due to a virulent strain of the *Bacillus coli* which sets up a catarrhal inflammation of the bowel of the young lamb. The inflamed bowel is then attacked by the *Bacillus Welchii*, which causes the formation of ulcers. Through these ulcers both the bacilli invade the system of the lamb and

cause death. The *Bacillus coli* invades the entire body, but the *Bacillus Welchii* may not invade the body farther than the liver.

The lamb dysentery investigation is now at the stage of experiments regarding field immunisation, or the discovery of other practical means whereby the enormous losses from this disease may be prevented. In the affected areas no less than one-third of all the lambs born die from lamb dysentery.

An interesting feature of the investigations into braxy in sheep and lamb dysentery is the bearing they have upon human pathology. The causal bacillus of braxy is identical with one of the bacteria found as the cause of gas gangrene in war wounds in man. The *Bacillus Welchii*, which plays a part in lamb dysentery, is also one of the bacteria found in gas gangrene from war wounds in man, and just as in man this bacillus seemed to produce its deadly effects only when associated with other bacteria, so in lamb dysentery it only seems to produce disease when acting along with the virulent strain of *Bacillus coli*. Had these two animal diseases been thoroughly investigated before the war period, valuable time would have been saved in the investigation of human gas gangrene during the war, and doubtless many valuable lives would have been saved also.

Virus Diseases.

The next four specimens, Nos. 6-9, illustrate diseases caused by ultravisible viruses—that is to say, causal agents which are too small to be seen by present-day microscopes.

No. 6 shows the ulcers found in the intestines of pigs affected with *Swine Fever*, a disease which causes heavy annual mortality in Britain. There is an efficient method of preventive inoculation for this disease.

No. 7 shows the head of a fowl affected with *Roup* or *Contagious Epithelioma*, a disease which causes serious losses in poultry in Britain. A method of preventive inoculation has been extensively used in America, but has not been used to any extent in this country.

Nos. 8 and 9 illustrate the mouth lesions in *Foot-and-Mouth Disease* in cattle, a disease with which most parts of this country have been familiar recently. The disease spreads with great facility, and, while the percentage mortality is not great, causes serious economic losses in cloven-footed animals. No effective method is known of conferring immunity to the disease upon healthy animals.

Specimens 10, 11 and 12 illustrate tumors in domestic animals. No. 10 shows a malignant new growth known as *Melanotic Sarcoma* in the hind leg of a dog. The primary tumor is seen in the dog's foot, and the spread of the tumor is seen in the numerous secondary growths along the course of the lymphatic vessels of the leg. A metastatic (distant) growth removed from the skin of the dog's shoulder is also shown.

Tumors.

No. 11 shows a form of *Cancer* spreading widely over the inner lining of the abdominal cavity (*peritoneum*).

No. 12 shows a not uncommon form of tumor (*Psammona*) in the brain of a horse. Two tumors are present in this case. Such tumors may become quite large before causing any symptoms, but these eventually appear suddenly and cause death.

Specimens 13, 14 and 15 afford examples of parasitic (*Metazoa*) diseases in animals, a class of diseases about which a very great deal is now known.

Parasitic Diseases.

No. 13 shows a *Parasitic Aneurism* from a horse. The blood vessel, which has become a solid clot of blood, has been laid open lengthwise to show the contents. When any number of blood vessels or any vitally important blood vessel is thus affected the condition becomes fatal.

No. 14 shows a heavy infestation of a young pig's liver with *Cysticercus tenuicollis*. The tracks, which are the wanderings of the young cysticercus, are well seen. A heavy infestation, as in this pig, means death.

No. 15 shows the cavity formed in the brain of a sheep by the bladder worm—*Coenurus cerebralis*—which sets up the familiar symptoms known as Gid or Sturdy.

Specimen No. 16 illustrates losses in animals due to *poisonous plants*. The root shown is that of Water Dropwort (*Oenanthe crocata*), and was from a number of such roots which caused the death of several cattle in Ayrshire.

Poisonous Plants.

The exhibit (Case U) of the **Institute of Agricultural Helminthology (London School of Tropical Medicine)** illustrates work which is being carried on in the identification of parasitic worms occurring in domesticated animals and plants, the study of their structures and life history, and the mode of infection. The study of parasitic

Parasitic Worms.

worms (technically known as *helminths*) is quite old, and at one time they were regarded as the agents of diseases in general. Many of the diseases have since been shown to be of bacterial origin, or the result of deficient food and of other causes, but the parasitic worms still play an important part in giving rise to disease conditions in many of the organs of the body.

Bay " A " shows the organisation of the Institute and its relation in Central London to the leading Scientific Libraries and to its chief sources of research material—viz., the Metropolitan Meat Market, the Zoological Gardens, and the Hospitals of the Seamen's Hospital Society. Material also arrives from abroad through overseas activities and connections of the London School of Tropical Medicine. Subsidiary centres for research are at Aberystwyth and at Harpenden, where officers of the Institute are provided with facilities for studies under field conditions by the local research Institutes and Colleges.

Eelworms attacking Plants.

Bay " B " shows the nature of the diseases in various plants caused by eelworms. These eelworms vary in size from 1/50th to 1/15th of an inch, and may be divided into (a) those attacking the stem structures above the ground—such as leaves, or underground—such as bulbs and tubers, shown on panel B1, 2, and (b) those attacking the roots shown on panel B3. Amongst the plants of economic importance that are attacked are wheat, clover, oats, potatoes, rice, narcissus, chrysanthemum, strawberries, fern, black-currants, and coconut palms. The roots of tomatoes, cucumbers and beet are subject to attacks which result in enormous losses. The central panel shows a photograph of a field of narcissus : the patch in the foreground is infested with eelworms, the rest of the field is unaffected.

Worms attacking Animals.

Bay " C " illustrates on successive panels, as detailed on Panel C1, the morphology of adult worms, their eggs, carriers, the development stages of parasites, and the pathology and pathological-histology of worm infections.

Panel C2 shows, by common examples, some of the chief types of parasitic worms, including flukes, amphistomes and bilharzia worms, tapeworms and round worms ; their differences in shape are notable, but the internal differences in structure give the characters upon which the differential diagnosis is based.

Panel C3 shows by illuminated transparencies the different designs of the eggs of parasitic worms. These differences, as seen by microscopical examination of samples of the droppings of infected living animals, enable the specialist to diagnose infection during life.

Carriers and Hosts.

Panel C4. Many of the parasitic worms are spread by direct infection—i.e., the eggs passed in the droppings contain, or develop after some delay, a minute living worm, which may remain enclosed in the egg shell, and so be taken in as a contamination of food by another animal or it may hatch out after some delay, migrating on to the grass and be similarly swallowed, but many of the minute worms enter the bodies of other animals, such as earth-worms, leeches, water-fleas, crabs, mosquito-wriggles and snails, therein undergoing a further development before reaching the infective stage. In some cases a further migration into the body of another snail, or a crab or fish, is necessary before this infective stage is attained. These carriers are known as intermediate hosts, of which examples are shown on the Panel C4.

Panel C5 illustrates some stages in the migration of the microscopic young during their wanderings outside the body or in the carrier hosts; certain of these forms like the hook-worm and bilharzia worm enter the system of domesticated animals by piercing the skin.

Tissue Changes caused by Parasites.

Panel C6 shows the nature of the gross changes in the tissues of various organs caused by the presence of different types of parasitic worms. These in general consist of local gall-like reactions, or local erosions or occlusions. The examples shown include the "Lung-fluke" of dogs, "Gapes" in chickens, Worm nodule in Australian Beef, Pimply-Gut in cattle, Bilharziosis of the Bladder in man, Tapeworms in the horse.

Panel C7 also illustrates the local reactions caused by worms, but shows these changes (by microphotographs) as seen under high-power magnification.

The Dog as a Cause of Disease.

Bay "D" has on its centre Panel D2 an illuminated "silhouette" showing the farmer and the various animals on the farm grouped around the dog. The dog plays a valuable role on the farm, but to the student of helminthology he also plays, unconsciously, a sinister part in being the essential cause of disease in man, cattle, sheep, goat, horse, rabbit and mouse. In these

animals large cystic tumours may develop through contamination with dog droppings, which contain the microscopic eggs of adult tapeworms, which the dog alone harbours. A tapeworm discharging these minute eggs (which are just visible to the naked eye) is shown in the transparency beneath the silhouette. Five different tapeworms living commonly in the intestines of the dog are shown. Each of these gives rise to its own special type of cyst in some farm animal. Each type is shown in the lower part of this Bay beneath the tapeworm responsible, but the adult tapeworm causing the cysts in the mouse is not yet known. These cysts affect the brain, mesentery, liver and the connective tissues of the animals affected. The adult tapeworms show a marked range in size. The smallest is the minute *Taenia echinococcus*, measuring only $\frac{1}{4}$ in. in length, but giving rise to enormous cysts in man, cattle, pigs, goats and sheep, while *Taenia ovis* (shown in transparency beneath the silhouette) measures over 2 ft. in length.

On the right-hand Panel D1 are shown parasites of the dog which are peculiar to and give rise to disease in dogs alone.

On the left-hand Panel D3 are shown parasites which are peculiar to and give rise to disease in sheep.

FARM ACCOUNTING.

The business side of farming is at least quite as important as its technical side. That this has been recognised in the organisation of agricultural research will be gathered from the charts and tables shown by the **Institute for Research in Agricultural Economics of the University of Oxford** (Screen V). Further, the recen tappointment of Advisory Officers at certain provincial centres for the special purpose of watching and directing farm accounting will contribute to impress upon individual farmers the importance of the subject, and to guide them as to the right methods to employ.

Charts 1 *to* 6 illustrate the influence of prices on cereal growing in England and Wales since 1868. The changes in acreage are measured from the base of 100, the average for the five years 1868-1872. The price is measured in sterling value per quarter from the base of 100, which represents the average price in the ten years 1868-1877, the base years for the Sauerbeck-Statist Index Number of Prices. This price, however, is a "crude price" only, and does not represent the actual purchasing power of a quarter at a given time, because considerable changes in the purchasing power of money occurred during the period. A reduction in the price of any cereal need not lead to a reduction in acreage if it is accompanied by a proportionate reduction in prices of other goods and services —especially those purchased by the cereal grower—for the purchasing power of a quarter of grain would then remain constant. Conversely, an increase in prices need not lead to an increase in acreage if it is accompanied by an increase in general prices. Consequently, a line showing the comparative purchasing power of each of the three grains in the different years has been obtained by bringing the **grain prices** into relation with the course of **general prices** as indicated by the Sauerbeck-Statist Index Number.

Chart 1 shows the influence of prices and purchasing power of wheat on the acreage planted in each year. It shows that price changes had considerable effect on the acreage of wheat planted ; but it also indicates that the price of the wheat itself is not the sole factor in determining the acreage. The other factors of chief importance are the special costs of growing the wheat crop, which may not vary with general prices and costs, and the comparative prices and profits which may be realised at any time from alternative lines of production.

Chart 2 shows the close influence of price of barley on acreage planted.

Chart 3 shows the influence of prices on planting of oats. This chart is remarkable in that it shows the acreage increasing as the price falls. The probable explanation is that the oat crop is mainly used for animal feeding, chiefly on the farms on which it is grown. Thus as the market for animal products was better than that for the cereals grown for sale, the oats took a larger share of the land in the crop rotation, and the increase in acreage of oats helped to balance the decrease in acreage of other cereals.

Chart 4 shows the combined acreage of the three grain crops—wheat, barley and oats—with the combined prices for the three grains. This chart indicates the influence of the oat crop in the maintenance of the total area under the chief grain crops.

Chart 5 shows the changes in total arable acreage, together with the changes in the acreage of each of the three grain crops, and in the combined acreage of the three crops. The space between the line for the combined grain crops and that for the total arable land shows the area occupied by other crops. This chart indicates that there has been little change in the relative areas covered by grain crops and other arable crops, and indicates the influence of grain crops on total arable area.

Chart 6 shows the changes in total arable land, in acreage of wheat, and in cash wages of farm workers. It is difficult to obtain accurate records of wages in each year, but the index numbers used have been based on the best data available. There is, however, no doubt that the representation of the general trend of wages is fairly accurate.

The next exhibit comprises two tables constructed to show how the size of the farm influences the nature of the business carried on, and the efficiency of organisation.

Table 1 contains the results of a survey of a considerable district, farmed under conditions of mixed farming, classified according to the size of the farms and the nature and quantity of the produce sold. It will be noted how the tendency to develop dairying varies inversely with the size of the holding, whilst corn-growing increases with acreage. Meat production, potato growing and sales of hay are influenced very little by acreage, but sheep farming, as indicated by sales of wool, and the selling of straw, are both incidents of the larger holdings.

Table 2 shows the influence of size of farm on the efficiency of manual and horse labour. Results are given from three large districts, widely separated and representative of very different farming conditions, but in each case the

results are the same—the efficiency of labour, both manual and horse, increases as the size of the holding is increased.

The first exhibit below the foregoing, *Table* 3, shows the average labour requirements of crops and live stock, stated in "man-days per annum." Much of the success of farming depends upon the arrangement of the cropping and stocking scheme so as to utilise a uniform amount of labour at all seasons of the year. The figures show the actual amount of labour required, and the seasons at which it is required can be inferred. Winter wheat and winter oats, for example, occupy men and horses in late autumn and late summer; potatoes require most labour in the late spring and early winter; the spring corn and roots dovetail in at other seasons. Cows occupy labour at all seasons, but other cattle and sheep provide work for the most part in the winter months when occupation on the land is at its lowest.

The place of the tractor in farming economy has not yet been clearly determined. Much depends upon the extent to which it can be kept in use throughout the year, and in *Chart* 7 is shown the extent of its usefulness, month by month, on three farms in different parts of England. Its employment has been divided into "draw-bar" work and "belt" work, and the results indicate that on the average farm of 300 acres or so the proportion of idle time is very high. Even in relatively busy months there are few weeks in which it can be regarded as fully occupied.

The last chart, *Chart* 8, deals with gross output in relation to gross expenditure and profits in two separate groups of farms and for one large combined group. "Gross Output" represents all sales; "Gross Expenditure" represents all the cash expenditure of the farm, including that on labour and on rent; the "Net Output" is obtained by deducting the expenditure on raw materials—e.g., feeding-stuffs, fertilisers, seeds, &c.—from the gross sales, and represents the total sum which is available for distribution between the owner of land, the farmer and the workers. Thus when profits are obtained the short column which shows "Distribution of Net Output" is equal to the "Net Output" shown in the "Gross Output" column. Where loss is suffered, as in Group A, that loss is equal to the difference between the columns showing respectively "Gross Expenditure" and "Gross Output." The chart indicates quite clearly the relation of purchases of raw materials to total sales, and shows to what a large extent British farming is a "manufacturing" business. In other words, the contribution of the agriculturists—owners of land, farmers, and workers—to production is measured

by the "Net Output" portion of the "Gross Output" columns. The rest is the contribution of raw materials which are purchased outside the farm. The distribution of their total contribution between these three parties is indicated by the different coloured portions of the separate column showing "Distribution of Net Output." The chart also indicates, as in the case of Group A, that raw materials are sometimes badly chosen for the particular types of production followed, and that this poor choice leads to bad financial results. Throughout the chart, the various items are measured, not per acre of land, but in relation to the quantities required to produce £1,000 value in "Gross Output" or sales. Other factors influencing the financial results of farming may be studied by this method, and in particular the results of different combinations of land, labour and capital under varying types of cultivation or systems of organisation may be studied in relation to net output, the possible reward for the whole agricultural group, or in relation to the distribution of net output, which is the actual reward to each of the three parties—owners of land, farmers and workers.

[OVER.

PUBLICATIONS OF THE MINISTRY OF AGRICULTURE AND FISHERIES AND OF THE BOARD OF AGRICULTURE FOR SCOTLAND.

The principal publications issued by these Departments are :—

(1) Leaflets, designed to cover a large number of subjects relative to agricultural and horticultural practice ;

(2) Miscellaneous Publications, each of which deals comprehensively with a subject of special importance ;

(3) A *Journal* containing articles of general agricultural interest as well as monthly notes on manures, feeding stuffs and farm operations ; and

(4) A weekly Agricultural Market Report on prices and supplies of agricultural produce.

LIBRARY OF THE MINISTRY OF AGRICULTURE.

The Ministry's Library at 10, Whitehall Place, S.W.1, is open daily from 10 a.m. to 5 p.m. (Saturdays 10 a.m. to 1 p.m.). It contains some 20,000 volumes relating to agriculture and files all the principal periodical literature, both British and foreign, bearing on the subject. Books may be borrowed by teaching and research staffs, students, farmers and others, on compliance with certain simple conditions.

THE INTERNATIONAL INSTITUTE OF AGRICULTURE.

The International Institute of Agriculture at Rome was established under an International Treaty of 7th June, 1905, and is supported by 70 separate Governments, including the self-governing Dominions and Colonies of the British Empire.

The Institute collects and disseminates information bearing upon the statistics and economics, and the theory and practice of agriculture. It keeps in touch with the general trend of agricultural activity throughout the world and watches such movements as co-operation, insurance and credit.

The chief serial publications are " The Monthly Crop Report and Statistics," " The International Review of the Science and Practice of Agriculture " and " The International Review of Agricultural Economics," the two last being quarterlies. It also publishes two Year Books of Statistics and Legislation respectively.

Further information may be obtained on application to the Officer-in-Charge of the Gallery.